Lehigh

University Catalog Edition—
Courses Offered for 1979-1981

The Legacy of
James Ward Packard

March, 1979

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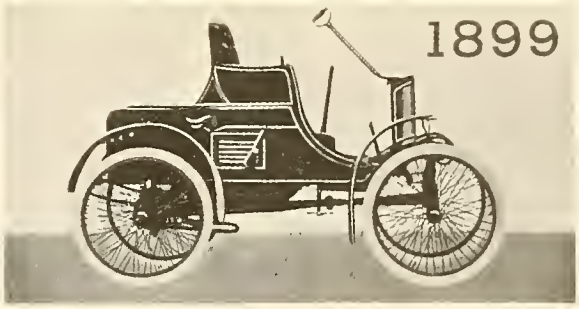

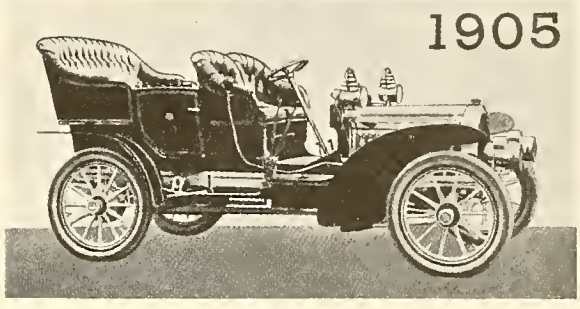

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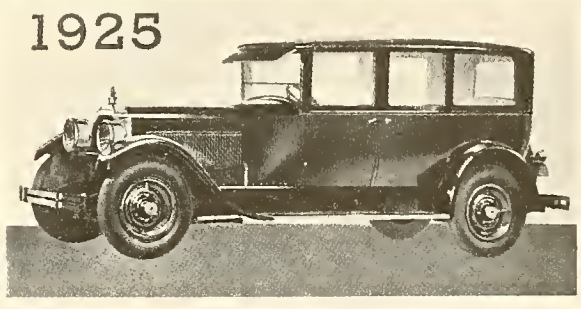

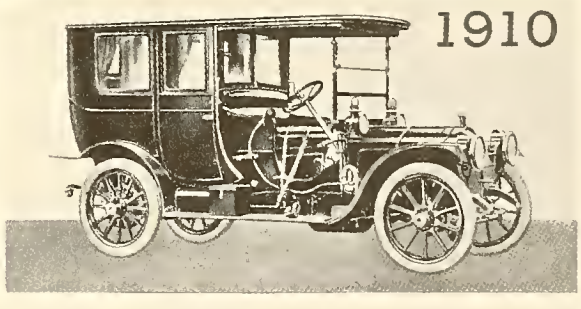

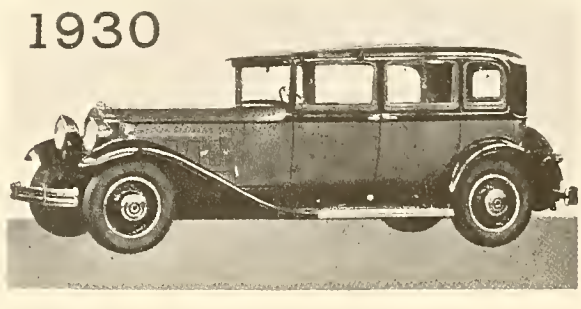

Every effort has been made to insure the accuracy, consistency and completeness of material in this edition. However, the editors refer the reader to a boast made by the editors of the 1771 edition of *Encyclopaedia Britannica*: "With regard to errors in general, either falling under the denomination of mental, typographical, or accidental, we are conscious of being able to point out a greater number than any critic whatever."

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March, 1979

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Lehigh University reserves the right to change at any time the rules and regulations governing admission, tuition, fees, courses, the granting of degrees, or any other rules or regulations affecting its students. Such changes take effect whenever Lehigh University deems them necessary.

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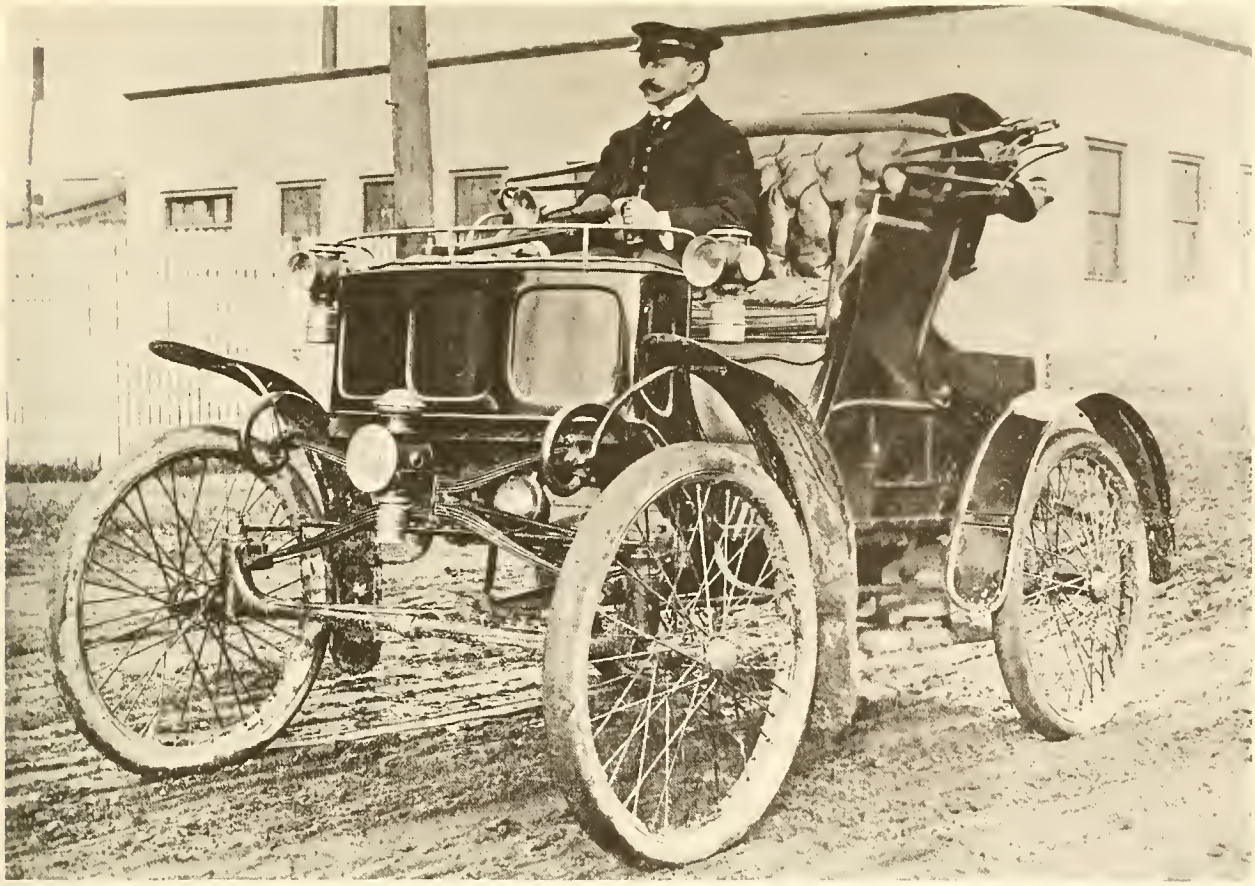

James Ward Packard's brother, W.D. Packard, takes the tiller of a 1900-model Packard. Sometimes the front wheels of such a car would catch in deep ruts and throw the driver out of the car if he held the tiller handle too tightly.

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Remembrance of Packards Past

Illustrations on the cover and throughout this edition of *Lehigh* relate to the illustrious Packard automobile, whose inventor, James Ward Packard, was a graduate of Lehigh in 1884. When his company was flourishing during the 1920s, Packard became a member of the university board of trustees and received the honorary doctor of engineering degree. He also built for Lehigh the Gothic-styled Packard Laboratory for Mechanical and Electrical Engineering, which today remains home base for the College of Engineering and Physical Sciences. The building was completed in 1929, just fifty years ago. The first Packard automobile ever built, model A-1, assembled in 1899, continues on permanent display in the lobby of the building. An account concerning Packard and his legacy to Lehigh appears on page 8.

All of the photographs are from the Lehigh University Archives, except for the one on the back cover, which is of recent vintage. Those interested in the archival collection may peruse the material by contacting Georgia Raynor.

The photographs of the Packards on the first and last pages were reproduced from a Packard catalog of the 1930s, made available by Robert B. Stauffer, of Palmyra, Pa.

Front cover photo: *The first transcontinental trip taken by an automobile was completed by this 1902 Packard, named "Old Pacific," and its driver, Tom Fetch, after thirty drivers in other cars had failed. The trip from San Francisco to New York took fifty-three days, at a top speed of twenty miles per hour.*

Back cover photo: *Lee A. Iacocca, '45, president of Chrysler Corporation and a member of the Lehigh University board of trustees, takes university president Dr. Deming Lewis for a spin around campus in the first Packard ever made.*

Academic Calendar

The Lehigh University academic calendar has evolved over the years to reflect the desires of students and faculty and the needs of the university as a whole.

Generally speaking, classes are scheduled Monday through Friday only. Typically, a three-credit-hour course is offered with either three fifty-minute class sessions Monday, Wednesday and Friday morning, or with two seventy-five minute classes on Tuesday and Thursday morning. Afternoon classes Monday through Friday are scheduled in either fifty-minute or seventy-five minute segments.

Students should note that the fall semester concludes prior to the holiday vacation period in December. To make this possible, classes commence at the end of August rather than in September. In the spring semester, classes begin following the holiday break between the semesters, and conclude in mid-May.

While every effort has been made to include correct dates in the calendar which follows, the faculty or the Forum on rare occasions make subsequent changes.

Spring, 1979

January 8-16 (Monday and Tuesday)—Graduate registration for the spring semester
January 17 (Wednesday)—Undergraduate registration for the spring semester
January 18 (Thursday)—Spring semester instruction begins
January 31 (Wednesday)—Last day on which registration for spring courses is permitted
February 22-24 (Thursday to Saturday)—Vacation
March 1 (Thursday)—Last day for filing application for degrees in May
March 19 (Monday)—Midsemester reports due
March 24 (Saturday) 1:10 P.M.—Spring vacation begins
April 2 (Monday) 8:10 A.M.—Spring vacation ends
April 2-6 (Monday to Friday)—Preregistration
April 12 (Thursday)—Last day for May doctoral candidates to deliver to the dean of the Graduate School the approved dissertation draft
May 4 (Friday)—Last day for May candidates for master's degrees to deposit with the dean of the Graduate School unbound copies of their theses; last day for October doctoral candidates to arrange for final examinations
May 5 (Saturday)—Last day of classes in the spring semester
May 7-8 (Monday and Tuesday)—Review-consultation-study period
May 9 (Wednesday)—Course examinations begin
May 11 (Friday)—Last day for May doctoral candidates to complete all requirements
May 17 (Thursday)—Course examinations end
May 27 (Sunday)—University Day (commencement exercises)

Fall, 1979

August 20-25 (Monday to Saturday)—Graduate registration
August 25-26 (Saturday and Sunday)—Freshman orientation
August 27 (Monday)—Undergraduate registration for the fall semester
August 28 (Tuesday)—Fall semester instruction begins
September 3 (Monday)—Holiday
September 4 (Tuesday)—Monday classes missed due to the holiday will meet; last day for October doctoral candidates to deliver to the dean of the Graduate School approved dissertation drafts
September 10 (Monday)—Last day for filing applications for degrees to be conferred on Founder's Day, October 14; first faculty meeting of the academic year
September 11 (Tuesday)—Last day on which registration for fall courses will be permitted
September 21 (Friday)—Last day for October candidates for master's degrees to deposit with the dean of the Graduate School unbound copies of theses
September 28 (Friday)—Last day for October doctoral candidates to complete all degree requirements
October 1-3 (Monday to Wednesday)—Engineering inspection trips
October 4 (Thursday)—Four o'clock quizzes
October 9 (Tuesday)—Four o'clock quizzes
October 10 (Wednesday)—Four o'clock quizzes
October 14 (Sunday)—Founder's Day, graduation exercises
October 15 (Monday)—Holiday
October 17 (Wednesday)—Monday classes missed due to the holiday will meet
October 22 (Monday)—Midsemester reports due
October 29 (Monday)—Preregistration for spring courses begins
October 31 (Wednesday)—Last day to withdraw from courses with a W
November 2 (Friday)—Preregistration ends
November 21 (Wednesday) 10 P.M.—Thanksgiving vacation begins
November 26 (Monday) 8:10 A.M.—Thanksgiving vacation ends
November 26 (Monday)—Last day for January doctoral candidates to deliver to the dean of the Graduate School their approved dissertation drafts
December 3 (Monday)—Last day for filing applications for degrees to be granted in January
December 8 (Saturday)—Last day of fall classes
December 10-11 (Monday and Tuesday)—Review-consultation-study period
December 12 (Wednesday)—Course examinations begin
December 14 (Friday)—Last day for January candidates for master's degrees to deposit with the dean of the Graduate School unbound copies of their theses
December 20 (Thursday)—Last day for January doctoral candidates to complete all degree requirements
December 23 (Sunday)—Course examinations end

Spring, 1980

January 7-12 (Monday to Saturday)—Graduate registration for the spring semester
January 14 (Monday)—Undergraduate registration for the spring semester
January 15 (Tuesday)—Spring semester instruction begins
January 28 (Monday)—Last day on which registration for spring courses is permitted
February 14 (Thursday)—Four o'clock quizzes
February 19 (Tuesday)—Four o'clock quizzes
February 20 (Wednesday)—Four o'clock quizzes
February 25-26 (Monday and Tuesday)—Vacation
February 27 (Wednesday)—Monday classes missed due to vacation will meet
March 3 (Monday)—Last day for filing application for degrees in June
March 6 (Monday)—Midsemester reports due
March 17-21 (Monday to Friday)—Preregistration
March 19 (Wednesday)—Last day to withdraw from courses with a W

March 20 (Thursday)—Four o'clock quizzes
March 25 (Tuesday)—Four o'clock quizzes
March 26 (Wednesday)—Four o'clock quizzes
March 27 (Thursday) 10 P.M.—Spring vacation begins
April 7 (Monday) 8:10 A.M.—Spring vacation ends
April 11 (Friday)—Last day for May doctoral candidates to deliver to the dean of the Graduate School their approved dissertation drafts
May 9 (Friday)—Last day for June candidates for master's degrees to deposit with the dean of the Graduate School unbound copies of theses; last day for October doctoral candidates to arrange for final examinations
May 3 (Saturday)—Last day of classes in the spring semester
May 5-6 (Monday and Tuesday)—Review-consultation-study period
May 7 (Wednesday)—Course examinations begin
May 16 (Friday)—Last day for June doctoral candidates to complete all requirements
May 18 (Sunday)—Course examinations end
June 1 (Sunday)—University Day, commencement

Fall, 1980

August 18-23 (Monday to Saturday)—Graduate registration
August 23-24 (Saturday and Sunday)—Freshman orientation
August 25 (Monday)—Undergraduate registration for the fall semester
August 26 (Tuesday)—Fall semester instruction begins
August 29 (Friday)—Last day for October doctoral candidates to deliver to the dean of the Graduate School approved dissertation drafts
September 1 (Monday)—Holiday
September 2 (Tuesday)—Monday classes missed because of the holiday will meet
September 8 (Monday)—First faculty meeting of the academic year
September 9 (Tuesday)—Last day on which registration for fall courses will be permitted
September 10 (Wednesday)—Last day for filing applications for degrees to be conferred on Founder's Day
September 19 (Friday)—Last day for October candidates for master's degrees to deposit with the dean of the Graduate School unbound copies of their theses
September 26 (Friday)—Last day for October doctoral candidates to complete all degree requirements
September 29-October 1 (Monday to Wednesday)—Engineering inspection trips
October 12 (Sunday)—Founder's Day, graduation
October 13 (Monday)—Vacation
October 14 (Tuesday)—Monday classes missed for vacation will meet
October 20 (Monday)—Midsemester reports due
October 27 (Monday)—Preregistration begins
October 29 (Wednesday)—Last day to withdraw from classes with a W
October 31 (Friday)—Preregistration ends
November 5 (Wednesday)—Four o'clock quizzes
November 6 (Thursday)—Four o'clock quizzes
November 11 (Tuesday)—Four o'clock quizzes
November 24 (Monday)—Last day for January doctoral candidates to deliver to the dean of the Graduate School approved dissertation drafts
November 26 (Wednesday) 10 P.M.—Thanksgiving vacation begins
December 1 (Monday) 8:10 A.M.—Thanksgiving vacation ends; last day for filing applications for degrees to be granted in January
December 6 (Saturday)—Last day of fall semester classes
December 8-9 (Monday and Tuesday)—Review-consultation-study period
December 10 (Wednesday)—Course examinations begin
December 12 (Friday)—Last day for January candidates for master's degrees to deposit with the dean of the Graduate School unbound copies of their theses
December 19 (Friday)—Last day for January doctoral candidates to complete all degree requirements
December 21 (Sunday)—Course examinations end

Spring, 1981

January 7-13 (Wednesday to Tuesday)—Graduate registration for the spring semester
January 14 (Wednesday)—Undergraduate registration for the spring semester
January 15 (Thursday)—Spring semester instruction begins
January 28 (Wednesday)—Last day on which registration for spring courses is permitted
February 18 (Wednesday)—Four o'clock quizzes
February 19 (Thursday)—Four o'clock quizzes
February 24 (Tuesday)—Four o'clock quizzes
March 2 (Monday)—Last day for filing application for degrees in May
March 7 (Saturday) 1:10 P.M.—Spring vacation begins
March 9 (Monday)—Midsemester reports due
March 16 (Monday) 8:10 A.M.—Spring vacation ends
March 25 (Wednesday)—Last day to withdraw from courses with a W
March 30-April 3 (Monday to Friday)—Preregistration
April 9 (Thursday)—Last day for May doctoral candidates to deliver to the dean of the Graduate School approved dissertation drafts
April 16 (Thursday) 10 P.M.—Easter vacation begins
April 21 (Tuesday) 8:10 A.M.—Easter vacation ends
April 23 (Thursday)—Monday classes missed for vacation will meet
May 2 (Saturday)—Last day of classes in the spring semester
May 4-5 (Monday and Tuesday)—Review-consultation-study period
May 6 (Wednesday)—Course examinations begin
May 8 (Friday)—Last day for May candidates for master's degrees to deposit with the dean of the Graduate School unbound copies of their theses; last day for October doctoral candidates to arrange for final examinations
May 15 (Friday)—Last day for May doctoral candidates to complete all degree requirements
May 17 (Sunday)—Course examinations end
May 31 (Sunday)—University Day, commencement

James Ward Packard, Class of 1884, test drives one of the Packard Motor Car Co.'s first "custom" models, built just after the turn of the century. The steering wheel became a standard Packard feature in 1901.

I. The University and Community

The author of the brief history of Lehigh University which follows, Dr. W. Ross Yates, holds the bachelor of arts and master of arts degrees from the University of Oregon, in his native sate. He also received the doctor of philosophy degree from Yale University and studied in France on a Fulbright Scholarship.

Dr. Yates joined the Lehigh staff in 1955 and served as dean of the College of Arts and Science from 1963 to 1972. Today he is professor of government.

Dr. Yates has written a history of the Lehigh Valley region and served as general editor of two volumes concerning the history of Bethlehem.

When the sound of the last cannon of the Civil War had died away, the statesmen, educators, and industrial pioneers marshalled the victorious forces of the North and turned their attention to education.

They sought to open a new chapter in the development of the Union by increasing the number of scientists, engineers, and other skilled people who could transform the vast natural resources of the country into a strong and independent national economy.

Asa Packer was one of the industrial pioneers. He had built the Lehigh Valley Railroad and controlled a coal-mining empire in the mountains of eastern Pennsylvania. He knew, as did many others, that a strong national economy depended on more than technical skills. It needed above all people broadly educated in the liberal arts and sciences—people who could combine practical skills with informed judgments and strong moral self-discipline. He kept this in mind in founding and endowing Lehigh University.

The bishop's account. The site which Packer chose for his university was a railroad junction across the Lehigh River from Bethlehem, the community founded in 1741 by Moravian missionaries. William Bacon Stevens, Episcopal bishop of the Diocese of Pennsylvania and the first president of the university's board of trustees, in 1869 described the origin of the university as follows:

"In the fall of 1864 an interview was requested of me by the Hon. ASA PACKER, of Mauch Chunk [now Jim Thorpe]. He came to my house in Philadelphia, and said that he had long contemplated doing something for the benefit of his State, and especially of the Lehigh Valley. From that valley he said he had derived much of the wealth which GOD had given to him, and to the best interests of that valley he wished to devote a portion of it in the founding of some educational institution, for the intellectual and moral improvement of the young men of that region.

"After conversing with him a little while, and drawing out his large and liberal views, I asked him how much money he purposed to set aside for this institution, when he quietly answered that he designed to give $500,000. At the time of this interview no one in this country, it is believed, had offered in a single sum such an endowment for a literary institution. It was the noblest offering which an American had ever laid on the altar of learning, and more than equaled many royal donations which have carried down the names of kings as patrons of European universities.

"Filled with profound emotions at the mention of such a gift for such an object, I asked the noble donor what specific plans he had framed in his own mind in reference to it. His reply was, 'I am not much acquainted with these matters, but

you are, and I want you if you will to devise a plan which I can put into effective operation.' I told him that I would make the attempt. I did so. I drew up the outline sketch of such an institution as I thought would give the largest results for the means used, and submitted it in a few weeks to his inspection.

"He examined it with the practical judgment and business habits with which he deals with all great questions, and adopted the scheme as the basis of his future university.

"The first meeting of the Board of Trustees, selected by JUDGE PACKER, met at the 'Sun Hotel,' in Bethlehem, July 27th, 1865, and began to organize the work before them."

The early years. The trustees followed several principles in setting up the university. One was that of combining scientific and classical education. They considered both to be practical. As Bishop Stevens pointed out, the principle carried forward an ideal of the great 17th-century Moravian educator, John Amos Comenius. A motto taken from the works of Francis Bacon was used to summarize this principle, namely, *Homo minister et interpres naturae*—man, the servant and interpreter of nature, to use a free translation. This motto appears today in the university seal.

The first five schools of the university included a School of General Literature in addition to four scientific schools of, respectively, civil engineering, mechanical engineering, mining and metallurgy, and analytical chemistry. The trustees sought as first president a man whose education and habits expressed this principle, ending their search by choosing Henry Coppee.

Another principle upon which the trustees insisted was that of keeping the size of the student body proportionate to the abilities of the faculty to teach them well. The university would admit only as many freshmen each year as it could be assured of providing with the highest quality of education. In the 19th century the total enrollment never exceeded several hundred students, although the size increased with the endowment and the number of faculty.

The trustees also insisted that Lehigh was to be nondenominational and would have an admission policy based on merit. Competitive examinations were held for applicants for admission. From 1871 to 1891 no tuition was charged.

At first the student body was entirely male. The ideological climate of the 19th century would permit nothing else. But, several decades after the establishment of graduate studies, around 1916, women were admitted to graduate programs. When by 1971 the climate of opinion had reversed itself on the question of educating women in practical scientific and engineering work, the university opened its undergraduate program to them as well as to men.

Flannel shirts. From the first, the students were serious-minded. In 1924 Catherine Drinker Bowen, daughter of president Henry Sturgis Drinker and later a famous biographer, published a brief *History of Lehigh University*, in which she commented:

"Ask any college professor which brand of boy he would prefer to teach, the cigarette brand or the flannel shirt variety. Right here we offer ten to one the flannel shirts. . .Lehigh still holds to the emblem of the flannel shirt—long may it wave! Engineers come to college to work. A writer in the *Syracuse Post* in 1895 spoke truthfully when he said, 'From the first, Lehigh's characteristic has been her earnestness. It is the boast of her graduates, the inspiration of her students. Men go there to learn to take a useful part in the economy of life'."

The students' ambition and zeal bore fruit; as alumni they carried the university's educational goals into the work of nation-building. And, having received, they gave to perpetuate Lehigh's work of service. The university community was constantly infused with new faculty and students determined to renew and rework the original principles in the light of changing times.

Today, Lehigh University still adheres to Asa Packer's goal of a liberal and scientific education for practical service. Faculty and students work to maintain quality. Faculty and administration seek income from individuals, foundations and government so that quality is retained while tuition is kept as low as possible. Present levels of tuition cover only about half the cost of a Lehigh education.

Tuition, under the conditions of the 20th-century economy, is unhappily with us. But it is not necessarily an evil. It becomes such in the measure that it tends to assign a dollar value to education. Packer knew that many could not comprehend the intrinsic value of the "practical and scientific education" which he desired. Tuition is somewhat more palatable when viewed as a contribution to the cause of education, which ultimately supports a way of life which Americans hold dear.

Lehigh is still a small university, lacking the enormous student bodies and the plethora of professional schools which characterize its larger cousins. At the beginning of 1979, Lehigh had approximately 4,300 undergraduates and 2,000 students enrolled in graduate programs.

An Overview. From the handful of buildings constructed amidst "a noble park of forest trees," as Asa Packer characterized the chosen locale, Lehigh University has grown to encompass some one-hundred buildings on the original South Mountain campus and on the relatively new 479-acre Saucon Valley campus to the south.

On a clear day, Lehigh students may not see forever, but the view afforded from a number of campus buildings usually extends northward across and beyond the host city of Bethlehem to the crest of the Kittatiny mountains some twenty miles distant. Along the northern horizons are the Appalachians and the famous Appalachian Trail which leads to termini in Georgia and Maine.

Lehigh alumni have gone to Georgia and Maine and far beyond, not by hiking but in a pursuit of professional excellence which has placed them across the nation and on foreign shores. Today's Lehigh men and women, fulfilling the promise expressed in the Alma Mater, "live to make their lives add lustre" to their university.

Accreditation

Lehigh University is accredited by the Middle States Association of Colleges and Schools.

Specialized programs in business administration are accredited by the American Assembly of Collegiate Schools of Business. The engineering curricula are accredited by the Engineers Council for Professional Development and the Council for Professional Development. Various School of Education programs are accredited by the National Council for Accreditation of Teacher Education, including Commonwealth of Pennsylvania approval for certification programs.

There are approximately 425 members of the faculty, teaching a total of 1,750 courses. Among faculty members who are tenured and to whom the university has a permanent commitment, some 85 percent hold the doctorate degree. Those with the doctorate make up 70 percent of the entire faculty.

The ratio of students to faculty at Lehigh is 14 to 1, whereas the national average is approximately sixteen students per faculty member.

In addition to the faculty and administrative people, the university employs some 600 supportive employees. In total, there are more than 1,500 salaried employees, about 200 wage employees and others, for a total of 1,800 persons.

Campuses: A Mountain and a Valley

The university is situated on the north slope of South Mountain overlooking Bethlehem, Pennsylvania. The Saucon Valley campus is located approximately two miles south of the main campus. The main campus encompasses approximately two-hundred acres while there are 479 acres comprising the Saucon Valley campus.

While the upper portion of the main campus remains in woodland, the area where classrooms are located is a kind of arboretum, with rare trees in abundance. In the spring, the magnolias planted by the university's sixth president, Henry S. Drinker, blossom. He was a leading naturalist.

Some of the trees predate the founding of the university. Others, such as the blue-flowering Chinese tree of heaven, are delicate newcomers. There are catulpas, cypresses, white birches, and massive English beeches as well as species more typically indigenous to the Middle Atlantic region. Of special interest is the Hutchinson collection of English boxwoods which graces the Alumni Memorial Building promenade.

Sayre Park, the wooded refuge which rises to the top of the mountain, is the setting for many living groups. The residences are reached via winding private roads.

The Sayre Park area is considered to be one of the most beautiful collegiate residential areas in existence, with a variety of contemporary and traditional student dwellings located in a kind of neighborhood of the young nestled into the mountainous, wooded site. All residential units on the campus afford for students a remarkable view of the entire Lehigh Valley. It can be said that, like the show tune, "on a clear day you can see forever." The foothills of the Poconos are visible to students across the expanse of valley.

Because of the unique setting, some interesting architectural treatments are possible. Several dwellings are entered from upper levels, and at least one is entered from the third floor, with the living room located on the fourth level. One dwelling has a small pond formed by a mountain stream at its backdoor.

A substantial portion of the upper level of the campus is maintained as a Nature Preserve, where students find quietude for studying outdoors when the weather is warm. The preserve includes flora indigenous to the area and wild animals in the natural habitat, including deer, squirrels, chipmunks, raccoons, and a variety of birds that would please any ornithologist.

Students of geology literally have field days on the campus. They might professionally describe the campus as located in the folded Appalachians, within a few miles of the Pocono Plateau, the Triassic Newark basin, the Crystalline Piedmont, the Atlantic Coastal Plain, and the Delaware Estuary. The area is rich in deposits of coal, zinc, iron and titanium.

Besides its Bethlehem campuses, the university also operates The Wetlands Institute, located on a thirty-four acre site adjoining a coastal salt marsh near Stone Harbor, N.J. The institute has several laboratories and dormitory space for students. The institute is concerned with the effect of pollution on marine life, and in general with the preservation and improvement of the coastal environment. Many undergraduates undertake study at the institute.

The board of trustees and university officers have established and enforce policies designed to preserve the natural beauty of the campus. It is their contention that the environment in which the young adult university student pursues knowledge can make the total educational experience more meaningful, and that the ideal environment is separate and unique from the distractions of the non-academic community.

Lehigh Presidents

Many individuals—alumni, faculty, students, friends—have made significant contributions to Lehigh University during the past hundred-plus years. Few, however, have been so visible in their contributions as Lehigh's presidents. Each of the ten presidents has brought different talents and experiences to the office.

Henry Coppee (born 1821, died 1895). Coppee served as a railroad engineer in Georgia, a captain in the Army during the Mexican War, and taught at West Point and at the University of Pennsylvania before becoming Lehigh's first president in 1866. Coppee wrote extensively in a number of fields, including military science and English literature.

During his tenure as president—which lasted until 1875—much building was done on the newly designated university campus. A Moravian church on Packer Avenue was purchased and remodeled into Christmas Hall, a house for the president was erected on campus, Sayre Observatory and Saucon Hall were completed, and Packer Hall (now the University Center) was erected.

Coppee's experience as a student and teacher at West Point was evident in many of his decisions. He applied West Point methods of discipline and teaching at Lehigh and modeled Lehigh's diploma after the oversize West Point diploma.

During Coppee's tenure, the divisions of the university were civil engineering, mechanical engineering, mining and metallurgy, analytical chemistry, and a school of general literature. Coppee himself lectured in history, logic, rhetoric, political economy, and Shakespeare.

John McDowell Leavitt (born 1824, died 1909). Dr. Leavitt was an Episcopal minister who graduated from Jefferson College and taught at Kenyon College and at Ohio University. During his incumbency, the university was divided into two schools, General Literature and Technology. As of 1876, a student could receive two engineering degrees by taking a longer course, and beginning in 1877 the master of arts, doctor of philosophy, and doctor of science degrees were awarded.

More building went on during the Leavitt administration. Linderman Library was completed in 1877, the gift of founder Asa Packer in memory of his daughter, Lucy Packer Linderman. Asa Packer died in May, 1879, and Founder's Day was held in his honor the following October.

Robert Alexander Lamberton (born 1824, died 1893). Dr. Lamberton became Lehigh's third president in 1880. A graduate of Dickinson College, Lamberton practiced law in Harrisburg and was a university trustee when asked to become president. During his administration, the first master of arts degree was conferred, and students and the community witnessed the first Mustard and Cheese dramatic presentation.

Building for the growing university continued. A gymnasium (now Coppee Hall) was erected, and Chandler Chemistry Laboratory was built at the personal expense of chemistry professor William H. Chandler. Packer Memorial Church was completed in 1878, a memorial to the founder provided by his daughter, Mary Packer Cummings. In addition to building a physical plant, Lehigh was also building its reputation for academic excellence; the mechanical engineering department was established in 1881 and the Lehigh chapter of Phi Beta Kappa was founded in 1887. Lehigh beat Lafayette in football for the first time in 1887.

Thomas Messinger Drown (born 1842, died 1904). Drown studied medicine at the University of Pennsylvania and went abroad to study chemistry. Thereafter he was professor of chemistry at Lafayette College for eight years. In 1895 he assumed the presidency of Lehigh and was greatly interested

in furthering Lehigh's development as a technical school. His first years were difficult ones; he was forced to face the possibility that Lehigh would have to close because the Panic of 1893 had ruined the university's stock holdings in the Lehigh Valley Railroad. This railroad had been founded by Asa Packer, who bequeathed the stock to the university.

Nevertheless, Lehigh managed to grow in enrollment, academics, and in physical plant. The physics laboratory burned and was rebuilt. Williams Hall was completed, the gift of the biology professor, Edward H. Williams, a graduate of Lehigh in 1875. The curriculum leading to a degree in arts and engineering was established, as was the department of zoology and biology. New curricula were adopted in metallurgical engineering, geology, and physics.

Henry Sturgis Drinker (born 1850, died 1937). Dr. Drinker, an 1887 Lehigh graduate, was the only university alumnus ever to serve as president. His appointment was symptomatic of the increasing alumni interest in university affairs. In 1907, the alumni endowment fund began, and the *Alumni Bulletin* was first published in 1913, and the Alumni Association was incorporated in 1917.

Drinker was general manager of Bethlehem Steel Company when he was tapped for the presidency in 1904. He started a tradition of businesslike management of university affairs.

During Drinker's fifteen years as president, Lehigh's endowment increased from $1.1 million to $3.1 million. More buildings were completed: the original section of Fritz Engineering Laboratory, Drown Hall, Coxe Mining Laboratory, Taylor House, Taylor Gymnasium and Field House, and Taylor Stadium. All of the Taylor facilities were gifts to Lehigh from financier Andrew Carnegie in behalf of his friend and business associate, Charles L. Taylor, Lehigh Class of 1876. The college commons, Lamberton Hall, was completed; today it is headquarters for musical organizations. Dr. Drinker's interest in horticulture led to the planting of many rare and interesting trees and plants, a large number of which survive today. Included among the plantings are flowering specimens from the Orient. Interest in these plants may have been related to the fact that Drinker was born in Hong Kong of American missionary parents.

A teacher's course and business administration course were begun in 1909 and in 1918 the university was divided into three colleges, liberal arts, business administration, and engineering—the roots of the three colleges of today. Evening classes commenced in 1920 and ROTC was established in 1919.

Dr. Drinker's daughter, Catherine Drinker Bowen, went on to become a writer of note. Her experiences as the daughter of a Lehigh president and occupant of the President's House are recorded in *Family Portrait* (Atlantic, Little-Brown). She also wrote *A History of Lehigh University*.

Charles Russ Richards (born 1871, died 1941). Dr. Richards was Lehigh's sixth president. He took office in 1922. During the thirteen years of his presidency, the first graduate degrees were awarded to women. Lehigh faced a shortage of students from 1929 to 1936 as a result of the Depression, but the newly established office of admission, as well as university scholarships, fellowships, and deferred tuition payments helped to ease the shortage.

Changing concepts of education were evident in several newly organized academic offerings: philosophy, music, psychology, journalism, history, and fine arts. The majors system was instituted and senior comprehensive examinations were instituted by the College of Arts and Science. The placement bureau, a public relations office, and a student health service were begun. The division of intercollegiate athletics and physical education was officially recognized during this period.

The Alumni Memorial Building—built in 1925 as a memorial to the Lehigh men who served in World War I—and Packard Laboratory were completed, the latter the gift of James Ward Packard, Class of 1884, the automotive inventor. Linderman Library's original rotunda was surrounded on three sides by extensive additions, presenting the Gothic facade seen today.

Clement C. Williams (born 1882, died 1947). Dr. Williams, a civil engineer by profession, became president in 1935. Not only did Lehigh celebrate its 75th birthday in 1941, but Williams' presidency saw an era of unprecedented alumni support of Lehigh. Undergraduate enrollment rose to an all-time high, passing 2,000 in 1938. Richards and Drinker residential houses, and the Ullmann section adjoining the Chandler Chemistry Laboratory were built. Eugene G. Grace, president of the board of trustees of the university from 1924 to 1956, provided funds to build Grace Hall, the first arena-type facility of any size on campus. The building was completed in 1940. Grace was chairman of the board of Bethlehem Steel Corporation.

A graduate school implemented the programs in the three colleges and the first Ph.D. since 1896 was granted. Williams retired in 1944, and Lehigh was without a president for approximately two years.

Martin D. Whitaker (born 1902, died 1960). Dr. Whitaker, who had served with the Atomic Energy Commission in the development of the atomic bomb, faced the responsibility of helping the university community readjust to peace after World War II. During his fourteen years as president, Lehigh's assets nearly tripled to $45 million; the endowment more than doubled to $18 million. Many buildings were renovated, and three new residence halls and five fraternity houses were built. The faculty increased in number by 75 percent and the first endowed distinguished professorships were established.

The most remarkable project associated with the Whitaker years was the Centennial development program, begun in 1959 with the aim of raising $22 million by 1966 for faculty salaries, the construction of a metallurgical and chemical engineering laboratory, an arts and science center, the Saucon Valley fields, student residences, and other needs. The campaign was a success.

An extensive renovation project was undertaken in Packer Hall in 1957, and a large addition was constructed to the west. This project was completed in 1958, at which time the building was renamed the University Center. The building serves as the hub of student activities.

Academically, the Whitaker years included the inception of an adult education program. Twenty departments offered the master's degree and twelve the doctor of philosophy.

Dr. Whitaker died in office.

Harvey A. Neville (born 1898). Dr. Neville, who continues to live in Bethlehem, took office in 1961. He was Lehigh's ninth president and the only faculty member ever elected president. His association with the university began in 1927 as an assistant professor of chemistry. During his three-year term of office as president, the first phase of the Saucon Valley playing fields complex was completed, and Sayre Field was opened atop South Mountain. The Center for Information Science was established and Lehigh acquired a site and began construction of a chemical engineering and metallurgical laboratory, which was named for Dr. Neville's predecessor, Dr. Whitaker.

The Neville Lounge in the University Center is named for the ninth president.

Deming Lewis (born 1915). Dr. Lewis became tenth president in 1964 after a distinguished career as a space engineer and research administrator. He entered Harvard University at age sixteen and received three degrees there, as well as two degrees from England's Oxford University, where he was a Rhodes Scholar in advanced mathematics.

In 1941, Dr. Lewis joined Bell Telephone Laboratories, and

in 1962 he was one of four Bell System executives who initiated Bellcomm, Inc., in Washington, D.C. Bellcomm engineered systems for the Apollo project which placed the first man on the moon.

Dr. Lewis holds thirty-three U.S. patents on such devices as microwave antennas and filters and digital error detection systems. He is a director of Bethlehem Steel Corporation and is active in many academic and eleemosynary organizations.

Many important academic programs have been developed at Lehigh during Dr. Lewis' administration. In 1964, the university's visiting committees—consisting of outside experts—were established to review university programs and suggest improvements. New programs have included majors in natural science, biology, social relations, geological sciences, environmental science and resource management and religion studies. Minors for engineering students in such fields as business, history, and social sciences were established. Interdisciplinary majors such as computer science, applied mathematics, management science, and American studies were instituted.

Five research centers and six institutes have been established, drawing faculty and gradnate students from a variety of departments. The graduate-level School of Education recently was reorganized into three special departments.

* * *

Gifts to the university have been unprecedented during Dr. Lewis's tenure. The first phase of the New Century Fund capital campaign yielded $1.1 million more than its goal of $30 million; the second phase, now in progress, has a goal of $42 million. During the 1977-78 academic year, Lehigh received a record $7,640,564 in contributions from all sources. Nearly fifty percent of all alumni make contribntions on an annual basis.

Since 1964, the university has grown dramatically in terms of physical facilities, with construction totaling more than $30 million. The buildings include Maginnes Hall, home of the College of Arts and Science; Whitaker Laboratory; Mart Science and Engineering Library; the Central Heating and Refrigeration building; Sinclair Laboratory; the $7 million chemistry complex; Rathbone Hall dining room; thirteen fraternity houses; the Centennial I and Centennial II residential complexes; the Trembley Park student apartment complex; the Saucon Married and Graduate Students apartment complex and the three sorority units located therein; the acquisition of the Saucon Valley athletic fields, totaling 479 acres, and the construction there of the Varsity House, the squash courts, the $1.86 million Philip Rauch Field House and the new $3.6 million Athletic and Convocation Center; the establishment of the Warren Square Cluster and Bishopthorpe Residence housing options in older buildings off-campus; and, under construction in 1979, a six-story apartment building for undergraduates.

A revolutionary action during the Lewis administration was the board of trustees' action admitting undergraduate women for the first time in 1971. This action changed the social climate at Lehigh, and also increased the size of the student body by approximately eight-hundred. An intensified effort to recruit blacks and members of other minorities has been undertaken, and the number of black students entering Lehigh in fall, 1978, was double the number in any previous year. Also, Reginald Jennings, a young Lehigh graduate, became the first black member of the board of trustees, followed in 1978 by the appointment of Mrs. Henry Kissinger as the first woman member of the board.

* * *

Increase in interest in Lehigh among prospective students has been dramatic. There were 2,837 applicants for 818 freshman seats in 1964, the year Dr. Lewis took office. Ten years later there were 3,490 applicants for approximately 1,000 seats. Then, for 1978, applications totaled 5,792 for the 1,000 seats.

In October of 1978, Dr. Lewis, working in conjunction with members of the faculty, made a dramatic move ato help sustain the level of quality at Lehigh. His administration established a compensation plan for faculty and professional employees which should help Lehigh in its effort to attract and retain people of quality. Essentially, the plan compares Lehigh compensation with that of a select group of universities and institutes, rather than an amorphous group used for comparison in previous years. The new group includes the following: Boston University, Carnegie-Mellon University, Cornell University, Duke University, Massachusetts Institute of Technology, Pennsylvania State University, Princeton University, Rensselaer Polytechnic Institute, Rutgers University, Stevens Institute of Technology, the University of Pennsylvania, the University of Rochester, and the University of Virginia. The compensation plan will commence with the fiscal year beginning July 1, 1979.

Although Dr. Lewis keeps busy with university affairs, he also finds time to relax. He has installed a pool table in the President's House for the amusement of his household, and he also is a frequent player on the sqnash courts. In addition, he recently completed the constrnction of a cabin cruiser, the Capricorn, with his own hands. The twin-engine vessel is docked at his summer home on the New Jersey shore.

Interestingly, Dr. Lewis is one of three Lehigh presidents who are natives of the South. Although his ancestors had arrived on the shores of New England in the early 17th Century, Dr. Lewis' parents were well established in Augusta, Ga., where he was born. The first president of Lehigh, Dr. Coppee, was a native of Savannah. A third southerner was Dr. Whitaker, who came from North Carolina.

Packard: The Name Lives On at Lehigh

November 6, 1899, was an historic day for Warren, Ohio, the automotive industry, and, indirectly, for Lehigh University. On that day long ago, the first Packard car rolled off the assembly lines at the firm called the New York and Ohio Company. It was quite a departure for a manufacturer of incandescent lights, dynamos, motors, transformers, cables, and other electrical apparatus, and it created a sensation wherever it went in Warren.

The car, dubbed the "Model A," was propelled by a twelve-horsepower, single-cylinder, horizontal engine. Power was transferred to the rear wheels through a single drive chain and the car had a reverse and three foward speeds, all operated through sliding and belt drives. Steering was by a shovel-handle tiller. The car had an open, buggy-style body, and pneumatic tires.

The Model A marked the beginning of automobile manufacturing in Warren. The Ohio Automobile Company was immediately formed as a subsidiary of the New York and Ohio Company and in 1900 twelve autos with an improved engine were completed. In 1903, the company was reorganized and established its headquarters in Detroit as the Packard Motor Car Company. Not long afterwards, it was world famous as a manufacturer of mechanically reliable luxury cars. Its slogan, "Ask the man who owns one," was so well known that company advertisements often featured that slogan with a picture of a Packard and no other identification of the vehicle shown.

Youngest freshman. The impetus behind that first Packard was James Ward Packard, an 1884 Lehigh University

graduate in mechanical engineering. Packard was born in Warren, in November, 1863, the son of a prominent local lumberman and sawmill operator. He demonstrated a mechanical ability early on in life and while still very young operated the electric light plant at Lakewood, N.Y. When Packard entered Lehigh, he was seventeen—the youngest man in his class.

After graduation, Packard moved to New York City, where he worked for a large electrical manufacturer, later becoming superintendent of the incandescent lamp department. He was a prolific designer, applying his mechanical talents and engineering training to a variety of electrical equipment and receiving more than forty patents for designs and improvements.

In 1890, Packard returned to Warren and in partnership with his brother established a company to manufacture incandescent lamps, motors, dynamos, cable, and other electrical equipment. This company became the New York and Ohio Company. But as early as 1891, Packard was fascinated by the European horseless carriages and bought a U.S.-built motor tricycle. In 1893, he and one of his shop foremen drew up plans for an automobile and Packard even tried to purchase an engine from a Detroit manufacturer. The depression of 1893 forestalled manufacturing the machine.

'If you're so smart. . . .' Tom Mahoney, in a 1950 issue of *Horseless Carriage Gazette*, recounts why Packard finally decided to build a car of his own. Packard, it seems, bought a one-cylinder vehicle made by Alexander Winton of Cleveland, the first American manufacturer to sell a car.

Unfortunately, Packard's purchase proved to be a lemon, and when he tried to drive it home from Cleveland, everything failed—the tires went flat, the driving chain broke, the engine ran hot, and Packard had to engage a team of horses to tow him and his new car home to Warren.

When Packard complained to Winton about the car and suggested some improvements, Winton, piqued by the criticism, snapped: "If you're so smart, Mr. Packard, why don't you make a car yourself?" Packard retorted, "I think I will!" And, with the help of some former Winton employees, he did. The Model A was the result, grandmother of the Packards that carried such notables as Czar Nicholas II of Russia, Harry S. Truman, Charles Lindbergh, Jean Harlow, Franklin D. Roosevelt, and Lehigh presidents Charles Russ Richards and Clement Clarence Williams.

The first Packard is now on permanent display at Lehigh, housed in a glass case in James Ward Packard Laboratory. The automobile and the building serve as memorials to James Ward Packard; he donated both to his alma mater.

In 1924, after nearly a year of intensive study, Lehigh published a booklet outlining the specifications for a much-needed structure to house the mechanical and electrical engineering departments. The booklet piqued Packard's curiosity and after examination he donated $1 million worth of Packard Motor Car Company common stock to Lehigh. When informed that construction costs had risen, he contributed another $300,000 to ensure that the laboratory would be "the finest of its kind."

In 1928, ground was broken for Packard Laboratory, and the building was dedicated in 1930. Among the materials used in its construction were 10,000 barrels of Portland cement, 789 tons of steel, and 334 tons of plaster. Unfortunately, James Ward Packard never lived to see the result of his largesse. He died in March, 1928, leaving one-third of his estate to Lehigh. Today Packard's endowment to Lehigh continues to be the second largest held by the university, exceeded only by founder Asa Packer's gift. The market value as of June 30, 1978, was $3,494,048.

Car gets around. The Model A Packard arrived in the early 1930s and was placed on display. It remained in its glass case for years, but it has left the campus several times recently. In 1967, Thomas E. Jackson, now adjunct professor of mechanical engineering, repaired the car so that it could be used to lead the parade that opened the Route 378 highway into Bethlehem. In 1974, the Packard was shipped to Warren, Ohio, to help the community celebrate its 175th anniversary.

Jackson still serves as curator for the vehicle and has driven it on several occasions. Driving it, he says, "is a real thrill. It takes two people to start the thing, but once she's going she does okay. At top speed on a level road, she moves right along at 25 to 30 miles an hour with two people riding. She'll even take a slight grade in low gear."

Lehigh's Packard, Jackson says, is the oldest car in the world that is still in instant running condition.

University Buildings

During the past dozen years, the university has constructed about thirty new residential and academic buildings with an aggregate cost of approximately $40 million. These structures provide more than one million square feet of space. The university now has more than one-hundred buildings.

Most recent of the structures are the Sherman Fairchild Laboratory (1976), the chemistry complex (1975), and the Philip Rauch Field House (1975). Residential facilities are described later in this section.

Two of the earliest buildings are known for their unique Railroad Gothic architecture. The prime example is the University Center, hub of student activities. The other is the President's House, located midway between the Alumni Memorial Building and the University Center.

Campus landmarks

The University Center (1868), originally known as Packer Hall. When construction began in 1865, a railroad was built to transport stone to the site. The building was extensively renovated and enlarged in 1958, but the Railroad Gothic exterior was retained.

President's House (1869). This is the home of university president Deming Lewis and Mrs. Lewis. Visiting dignitaries are entertained at the residence.

Packer Memorial Church (1887). The church was the gift of Mary Packer Cummings in memory of her father, university founder Asa Packer.

Alumni Memorial Building (1922). This Gothic edifice, housing administrative offices, is a memorial to Lehigh alumni who served in World War I.

Linderman Library (1877). The rotunda was built by founder Asa Packer as a memorial to his daughter, Lucy Packer Linderman. The Gothic facade on three sides was constructed in 1929. The building houses 490,000 volumes and the rare book collection.

Academic and research facilities

Chandler-Ullmann Hall (1910, 1938, respectively). These adjoining buildings formerly were individually identified as the William H. Chandler Chemistry Building and the Harry M. Ullmann Chemistry Laboratory. Chandler served as acting university president from November, 1904, to June, 1905, and taught chemistry from 1871 to 1906. Ullmann served as chairman of the chemistry department. In 1975, the chemistry department moved into the Seeley G. Mudd

Building and the combined name was adopted. The fine arts and psychology departments, the Marine Geotechnical Laboratory and the division of speech and theater are located in Chandler-Ullmann.

Christmas-Saucon Hall (1865, 1872, respectively). Christmas Hall is the university's oldest building. When Asa Packer acquired the South Mountain site for the university in 1865, a Moravian church was being constructed. The newly formed university took over the building and completed it for use in recitations and as a dormitory and chapel. The name Christmas Hall was chosen in keeping with the Moravian religious tradition. In 1872, Saucon Hall was constructed a short distance to the east of Christmas Hall. The buildings were connected with the construction of a "hyphen" in 1926.

Coppee Hall (1883). The building was originally a gymnasium. It is named in honor of Henry Coppee, first president of the university. Today the building houses the department of modern foreign languages and literature.

Coxe Laboratory (1910). Originally a mining laboratory, the structure honors the memory of Eckley B. Coxe, a pioneer mining engineer and a trustee of the university. The university dropped its mining engineering curriculum several years ago. The building now houses the Materials Research Center.

Drown Hall (1908). Erected by friends and alumni, the building honors Thomas M. Drown, president from 1895 to 1904. The building is headquarters for the College of Business and Economics.

Fritz Engineering Laboratory (1909, 1955). The laboratory honors the memory of John Fritz, father of the steel industry in the United States and a member of the university's original board of trustees. Mr. Fritz provided funds for the original section; a seven-story addition was built more recently and accommodates the university's testing machine, which is capable of applying a five-million-pound load to tension or compression members up to forty feet in length. The hydraulic testing machine is the second-largest such facility in the world. The laboratory is used by the department of civil engineering.

Johnson Hall (1955). The building houses the university health service, the counseling service, the personnel office, the chaplain, and the motor vehicle office. The building honors the memory of Earle F. Johnson, '07, who was a director of General Motors, and made a major contribution toward the structure. The gift was made anonymously, but during 1976 the university obtained permission from Mr. Johnson's family to name the building in his memory.

Lamberton Hall (1941). The structure originally served as the university commons and dining room until the renovation of the University Center was completed in 1959. The building honors the memory of Robert A. Lamberton, third president of the university, who served from 1880 to 1893. Today the structure houses the music department.

Maginnes Hall (1970). The contemporary multilevel structure is headquarters for the College of Arts and Science and also houses the departments of English, history, government, international relations, classics, and religion studies. The university bookstore is located on the ground floor. The building is named for Albert B. Maginnes, '21, a lawyer and trustee of the university from 1954 to 1966. Mr. Maginnes was the father of Nancy Kissinger, wife of the former U.S. secretary of state. She was named to the university board of trustees in 1978, the first woman member in the board's history.

Mart Science and Engineering Library (1968). This contemporary structure honors the memory of Leon T. Mart, '13, and his son, Thomas, '51. The library houses more than 130,000 volumes in the fields of engineering, mathematics, and natural and physical sciences.

Philosophy Building. This small structure near Packer Memorial Church served for many years as the chaplain's residence. Today it is the home of the philosophy department. The year of construction is not known, but it is very old.

Packard Laboratory (1929). The structure was the gift of inventor James Ward Packard, '84, the automotive and electrical pioneer who served as a university trustee in 1927 and 1928. The first Packard automobile (1898) is displayed in the lobby. The building is the headquarters for the College of Engineering and Physical Sciences and also houses the classrooms and laboratories for the departments of electrical engineering, industrial engineering, and mechanical engineering and mechanics. Packard Laboratory Auditorium accommodates large classes and many campus events.

Physics Building (1892). This massive five-story stone structure (240 feet long) was extensively renovated in 1960-61. It contains laboratories and teaching facilities for undergraduates and graduate students in the field of physics.

Price Hall. This structure formerly was a brewery named "Die Alte Brauerei." In 1912 it was remodeled to serve as a dormitory, and it was named in honor of Henry Reese Price, a president of the university board of trustees from 1912 to 1924. Today it serves the social relations department.

Rathbone Hall (1971). This student dining facility, with its window walls affording a superb view of the Lehigh Valley, honors its donor, Monroe Jackson Rathbone, '21, president of the university board of trustees from 1957 to 1973. Mr. Rathbone was chairman of the board, Standard Oil Co. (New Jersey), now known as Exxon Corp., and was a major innovator in the oil industry. He died in 1976. The lower level of Rathbone Hall houses the residence operations office.

Seeley G. Mudd Building (1975). This seven-story tower provides a fine home for the chemistry department and both undergraduate and graduate students. The tower is part of the $7 million chemistry complex, which also includes an adjoining structure housing three large classroom-auditoriums. The late Dr. Mudd was a California medical doctor. The Seeley G. Mudd Foundation, of Los Angeles, made a major gift toward the building.

Sherman Fairchild Laboratory (1976). This $1.9 million research facility provides offices, laboratories and equipment for solid-state studies. It was the gift of the Sherman Fairchild Foundation, of Greenwich, Connecticut. The late Mr. Fairchild was an iconoclastic inventor who made significant contributions in a variety of fields. He was the son of the founder of IBM.

Sinclair Laboratory (1970). This contemporary research facility houses the Center for Surface and Coatings Research and the National Printing Ink Research Institute. It is named in honor of Francis MacDonald Sinclair, a New York City ink manufacturer, and was the gift of his widow, Mrs. Jennie H. Sinclair.

Wilbur Drama Workshop (1908). During most of its life, the building served as the university's power plant. Power now is produced in a modern structure a short distance away. The old building has been renovated so that it provides an open space suitable for theatrical productions.

Whitaker Laboratory (1965). This five-story structure with an adjoining two-level classroom-auditorium section honors the memory of Martin D. Whitaker, president of the university from 1946 to 1960. Dr. Whitaker had been director of the Atomic Energy Commission laboratory at Oak Ridge, Tennessee, before coming to the university. The buildings serve the department of metallurgy and materials engineer-

ing, and the chemical engineering department. There are laboratories for high pressure research and reaction kinetics, nuclear studies, analog computation, process control, high-temperature thermodynamics and kinetics, and fine structures and metallography.

Williams Hall (1903). This brick structure was the gift of the late Edward H. Williams, Jr., Class of 1975. Dr. Williams was a professor of mining and geology at Lehigh for twenty-one years. The building contains the classrooms and laboratories of the departments of biology and geological sciences. It also houses the Center for Marine and Environmental Studies. A greenhouse used by students of botany adjoins the building. Following a fire, the building was extensively renovated and a fourth story added in 1956.

Athletic Facilities

Athletic and Convocation Center (1979). This $3.6 million arena is scheduled for completion in time for commencement exercises in early June of 1979. It provides permanent seating for 6,000 persons for spectator sports and a variety of other events, particularly wrestling and basketball. University trustee Donald B. Stabler, '30, has pledged $1.25 million toward the cost.

Philip Rauch Field House (1976). During the fall of 1978, the university's field house, completed in 1976, was dedicated and named for the principal contributor, Philip Rauch, a member of the Lehigh Class of 1933. Mr. Rauch is chairman of the executive committee of Parker Hannifin Corporation, an international manufacturer of automotive replacement parts. The $1.86 million building has 62,000 square feet of uninterrupted floor space—the equivalent of two football fields—for a variety of athletic activities. It has a six-lane, one-eighth-mile flat track, surrounding the cushioned synthetic surface of the playing area.

Grace Hall (1940). The building is named for its donor, the late Eugene G. Grace, who was chairman of Bethlehem Steel Corporation and president of the university's board of trustees from 1924 to 1956. The building's lower level seats about 3,200 and is used for wrestling and basketball as well as concerts and lectures. The upper level accommodates the military science and aerospace studies departments.

Saucon Valley Fields (1968). The campus for athletic activities, located two miles to the south of the South Mountain campus, encompasses 479 acres. Facilities include a wide variety of playing fields and an outdoor track, as well as tennis courts. Use of the area began in the early 1960s. The university acquired the final sections of the tract in 1970.

Sayre Field (1961). Located atop South Mountain, the field is used for softball and other sports. Its high location affords players and spectators a sweeping view of the eastern Lehigh Valley. A comfort station is located on the site.

Squash Courts (1972). The building houses several courts.

Taylor Gymnasium and Field House (1913 and 1904). This structure was the gift of Charles L. Taylor, Class of 1876, who was a friend and business associate of steel magnate Andrew Carnegie. There are two indoor swimming pools, five basketball courts, a weight room and a fencing room.

Taylor Stadium (1916). The stadium, which seats 16,000 persons, is located on the eastern end of the main campus, on the site of the Athletic Grounds which opened in 1880. It is named for Charles L. Taylor, Class of 1876.

Varsity House (1963). The building houses lockers and other facilities for varsity teams using Saucon Valley Fields.

Power Facility

Central Heating and Refrigeration (1969). This contemporary building replaces the old Wilbur Power House, which was renovated and renamed the Wilbur Drama Workshop. The new facility is unusual in that its equipment is clearly visible to passersby on Packer Avenue through a glass front wall. There are three boilers in the building, and they can be fired either by oil or gas. Other equipment provides cold water for air conditioning some buildings.

Residential Facilities

Lehigh is primarily a residential university. Approximately eighty-two percent of undergraduates reside in university-owned or university-related facilities.

Some 2,100 students live in on-campus residence halls, which are listed below, and in the Saucon Married and Graduate Students apartments on the Saucon Valley campus, in the Bishopthorpe Residence located in nearby Fountain Hill, and in the German House, situated on Warren Square. An additional 1,100 men live in thirty-one fraternity houses, while approximately sixty women reside in three sorority houses.

Residence Halls

Brodhead House. This $2.1 million structure, which will house approximately two-hundred students when it is completed, is the university's first high-rise type of residential facility. The six-story building is scheduled to include student apartments on the five upper floors, with a dining facility and lobby on the entrance level. The building is situated just north and west of the campus in the South Side neighborhood. The building is named in memory of Albert Brodhead, a member of the Lehigh class of 1888 who died in 1933, leaving fifty-one Bethlehem properties to his alma mater. Completion of the building is expected in time for use by students in the fall of 1979.

Centennial I complex (1965)

Congdon House. Dr. Wray H. Congdon served as dean of students, dean of the Graduate School and special assistant to the president, retiring in 1961.

Emery House. It is named for Dr. Natt M. Emery, vice president and controller, who died in 1953.

Leavitt House. The Rev. Dr. John McD. Leavitt was the second president, serving from 1875 to 1879.

McConn House. C. Maxwell McConn was dean of the university from 1923 to 1938.

Smiley House. Dr. E. Kenneth Smiley served as vice president from 1945 to 1964.

Thornburg House. Named for Dr. Charles G. Thornburg, professor and head of the department of mathematics, 1895 to 1923. His grandson, Richard Thornburgh, is governor of Pennsylvania.

Centennial II complex (1965)

Beardslee House. Dr. Claude G. Beardslee was chaplain from 1931 to 1947.

Carothers House. Dr. Neil Carothers was dean of the College of Business and Economics from 1936 to 1949.

Palmer House. Dr. Philip M. Palmer was dean of the College of Arts and Science from 1936 to 1950.

Stevens House. The Rt. Rev. William Bacon Stevens was Protestant Episcopal bishop of the Diocese of Pennsylvania and first president of the university's board of trustees.

Stoughton House. Dr. Bradley Stoughton was dean of the College of Engineering and Physical Sciences, 1936 to 1939.

Williams House. Dr. Clement G. Williams was president of the university from 1935 to 1944.

Dravo House (1948). This stone edifice is the university's largest single residential facility. It honors two brothers, Ralph M. Dravo, Class of 1889, and Francis F. Dravo, Class of 1887, who founded the Dravo Corporation, a Pittsburgh-based international construction company. Both men served as university trustees.

Drinker House (1940). This stone building honors the memory of Henry S. Drinker, Class of 1871, who was university president from 1905 to 1920. He was the father of the late historian, Catherine Drinker Bowen, who was raised in the President's House.

McClintic-Marshall House (1957). This U-shaped stone structure was built in memory of Howard H. McClintic and Charles D. Marshall, both Class of 1888 graduates, who founded the McClintic-Marshall Construction Company. The firm became the world's largest independent steel fabricating firm before its merger with Bethlehem Steel Corporation in 1931. It built the locks for the Panama Canal and the Golden Gate Bridge in San Francisco.

Richards House (1938). The building honors the memory of Charles Russ Richards, president of the university from 1922 to 1935. The structure is constructed of stone with modified Gothic architecture.

Trembley Park (1975). This contemporary, seven-building, $1.86 million undergraduate apartment complex is located west of the University Center. It is named for the late Francis J. Trembley, pioneer in the field of ecology, who was responsible for saving many trees on the site of the complex.

Saucon Married and Graduate Students apartments (1974). This five-building garden apartment complex on the periphery of the Saucon Valley campus houses undergraduates and graduate students. The buildings in the $2 million complex are named as follows:

Diamond. Named for Dr. Herbert M. Diamond, of Bethlehem, professor emeritus of economics, who retired in 1964.
Gipson. Dr. Lawrence H. Gipson, research professor emeritus of history, bequeathed his $125,000 estate to the university to establish the Lawrence Henry Gipson Institute for Eighteenth-Century Studies. Before his death, in 1971, Dr. Gipson wrote a monumental fifteen-volume history, *The British Empire Before the American Revolution*. He won the Pulitzer Prize for volume 10, *The Triumphant Empire: Thunderclouds Gather in the West 1763-1766*.
Hartman. The late Dr. James R. Hartman was chairman of mechanical engineering and mechanics.
More. Dr. Robert P. More, dean of the College of Arts and Science, who also taught German for forty years, bequeathed to the university his $746,000 estate. He died in 1970.
Severs. Dr. J. Burke Severs, of Bethlehem, is distinguished professor emeritus of English. The widely recognized Chaucerian scholar retired in 1969.

Taylor House (1907). This U-shaped concrete structure was the gift of industrialist Andrew Carnegie in honor of his friend and associate, Charles L. Taylor, Class of 1876.

Fraternities and Sororities

The university has a strong fraternity tradition, dating back to 1872 when Chi Phi was established. The most recently established fraternity was Alpha Epsilon Pi, recognized in January, 1979.

Twenty-seven of the thirty-two Lehigh fraternities have houses located on campus, most in Sayre Park, while the other five have houses off campus. Contributions for construction and support of fraternity dwellings are made by chapter alumni.

All of the fraternities are chapters of national fraternities.

An alphabetical listing of Lehigh fraternities follows. The date of the founding of the chapter is given in the first column. The second column lists the date the chapter occupied its present house; additional dates indicate the most recent addition or major renovation.

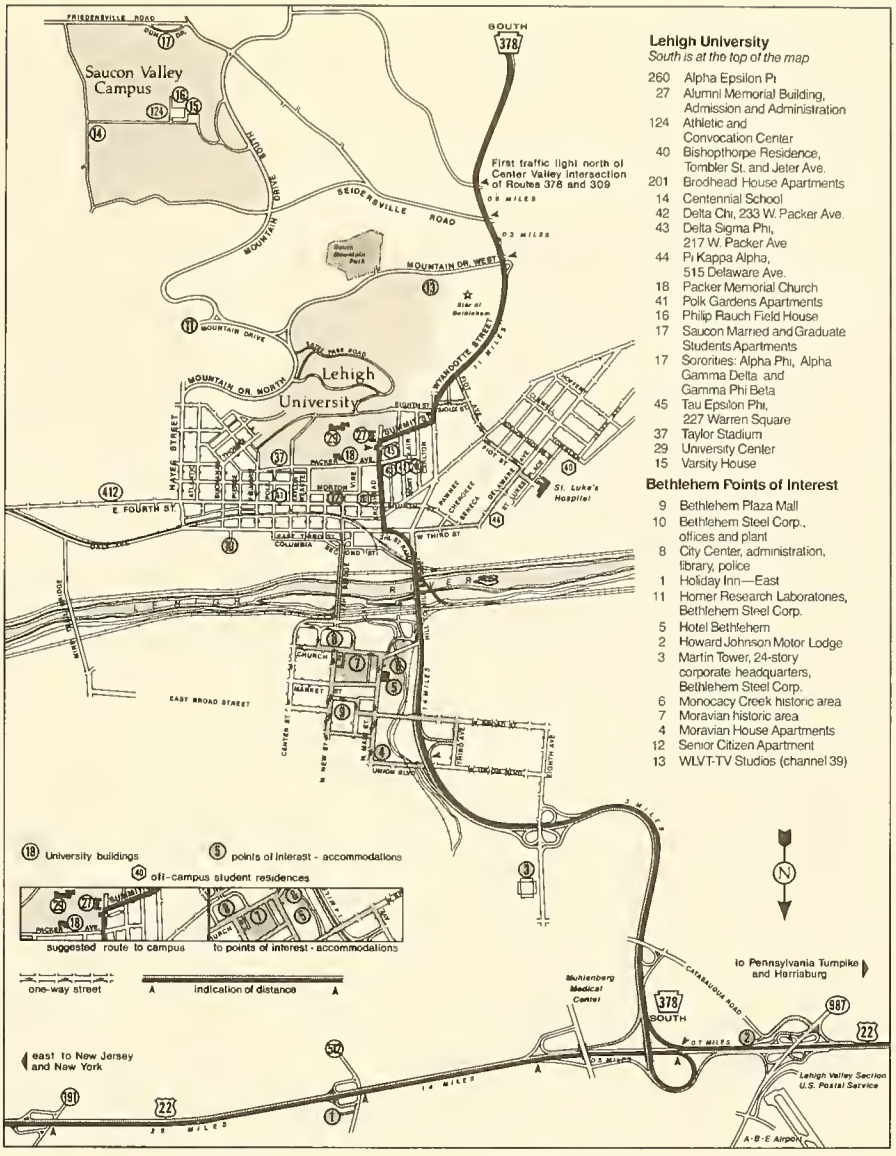
Alpha Chi Rho	1918	1968
Alpha Epsilon Pi	1979	1978
Alpha Sigma Phi	1929	1961
Alpha Tau Omega	1886	1966
Beta Theta Pi	1891	1968
Chi Phi	1872	1922, 1968
Chi Psi	1893	1916, 1955
Delta Chi	1952	1968
Delta Phi	1884	1963
Delta Sigma Phi	1931	1945
Delta Tau Delta	1874	1959
Delta Upsilon	1885	1968
Kappa Alpha	1894	1961
Kappa Sigma	1900	1973
Lambda Chi Alpha	1926	1962
Phi Delta Theta	1876	1919, 1963
Phi Gamma Delta	1886	1942, 1968
Phi Kappa Theta	1919	1966
Phi Sigma Kappa	1901	1957, 1970
Pi Kappa Alpha	1929	1903
Pi Lambda Phi	1915	1965
Psi Upsilon	1884	1909, 1966
Sigma Alpha Mu	1923	1966
Sigma Chi	1887	1953
Sigma Nu	1885	1970
Sigma Phi	1887	1950, 1961
Sigma Phi Epsilon	1907	1963
Tau Epsilon Phi	1963	1964
Theta Chi	1942	1964
Theta Delta Chi	1884	1937, 1967
Theta Xi	1904	1967
Zeta Psi	1973	1973

Not long after Lehigh admitted its first undergraduate women in 1971 the effort to establish sororities began. All are housed in separate units of the Saucon Married and Graduate Students apartments, which opened in 1973. The units were renovated to accommodate the sororities and the women moved in for the fall semester of 1977. Alpha Phi was the first to colonize, in 1975, but all three sororities received recognition from the university at the same time, on January 20, 1976. The others are Alpha Gamma Delta and Gamma Phi Beta.

Policy of Fairness

In accordance with applicable federal and state laws and regulations, it is the policy of Lehigh University not to discriminate in any way, whether it be with respect to employment, educational programs or otherwise, on the basis of age, race, sex, color, religion, creed, national origin or ancestry or because a person is handicapped or a Vietnam veteran.

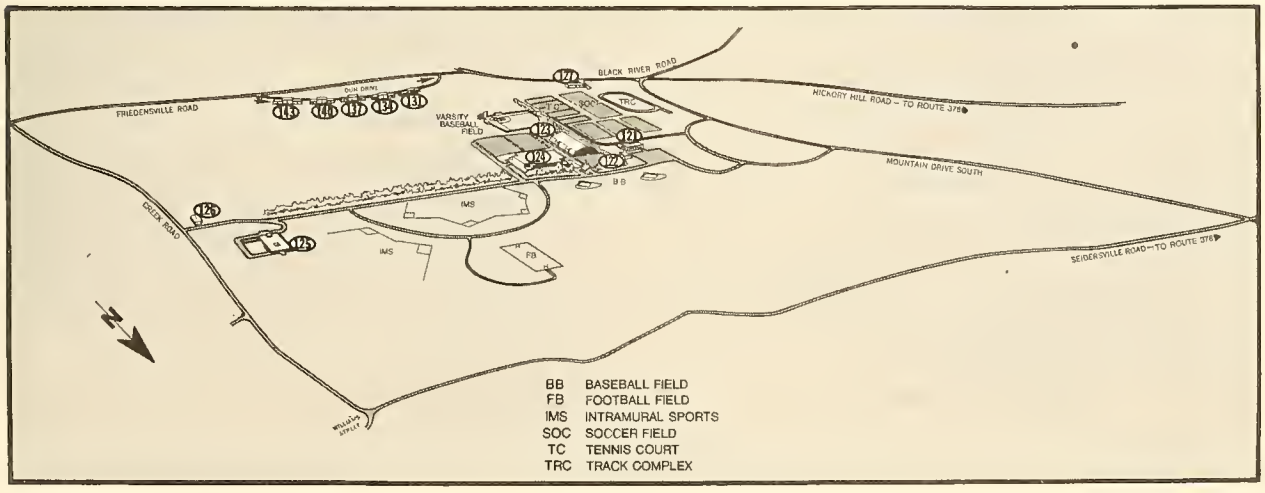
Maps



Lehigh's Saucon Valley campus, located in the area just to the south of the main South Mountain campus, encompasses 479 acres. Numerous athletic fields and tennis courts are located in the area. South in at the top of the map.

124 Athletic and Convocation Center (completion summer, 1979)
126 Centennial Manual and Fine Arts Annex
125 Centennial School
127 Maintenance facility
123 Philip Rauch Field House

131- Saucon student apartments (SMAGS):
143 Diamond
140 Gipson
137 Hartman
134 More
121 Severs
134 Gamma Phi Beta
137 Alpha Gamma Delta
140 Alpha Phi
122 Squash Courts
121 Varsity House



University Buildings

South is at the top of the map.

27 Alumni Memorial Building (admission and administration O-10
29 Campus Police headquarters (University Center) L-9
10 Central Heating and Refrigeration F-12
17 Chandler-Ullmann Hall I-10
6A Chemistry Auditoriums J-12
14 Christmas-Saucon Hall J-12
9 College of Arts and Science (Maginnes) M-13
35 College of Business and Economics (Drown) K-8
19 College of Engineering and Physical Sciences (Packard Laboratory) M-11
197 Computing Center Administration, 616 Brodhead Ave.
26 Continuing Education (Sayre Building) P-10
33 Coppee Hall J-9
32 Coxe Laboratory I-9
35 Drown Hall K-8
23 Education Building and Annex QR-11
2 Figlear Building L-15
36 Fraternity Management Association (Johnson) L-8
13 Fritz Engineering Laboratory I-11
11 Fritz Laboratory Office Building H-12
39 Grace Hall G-9
5 Graduate School office (Whitaker) I-13
36 Johnson Hall (health center, counseling service) L-8
34 Lamberton Hall J-8
30 Linderman Library J-9
9 Maginnes Hall M-13
8 Mart Science and Engineering Library K-13
41 Newman Association Center F-9
19 Packard Laboratory M-11
18 Packer Memorial Church K-11
15 Philosophy Building L-12
3 Physical Plant Office G-12
3a Physical Planning Office Annex G-12
16 Physics Building G-11
28 President's House N-9
40 Price Hall G-8
191 Purchasing office, 440 Brodhead Ave. Q-11
63 Rathbone Hall dining facility D-9
63 Residence Operations (Rathbone Hall, lower level) D-9
108 Sayre Park Field and comfort station E-3
26 Sayre Building (Continuing Education) P-10
23 School of Education, 516-524 Brodhead Ave. QR-11
6 Seeley G. Mudd Chemistry Building IJ-12
1 Service Building (Allied Maintenance Co.) H-16
161 Sherman Fairchild Laboratory for Solid-State Studies H-10
7 Sinclair Laboratory J-13
203 Small Business Center, 412 S. New St. M-15
195 Summer Session Office, 219 Warren Square S-11
38 Taylor Gymnasium and Field House F-10
37 Taylor Stadium CDE-11
24 Town House Q-10
29 University Center (Packer Hall) L-9
5 Whitaker Metallurgical and Chemical Engineering Laboratory I-13
12 Wilbur Drama Workshop G-11
31 Williams Hall H-10

Research Centers and Institutes

4 Center for the Application of Mathematics G-12
35 Center for Economic Education (Drown) K-8
19 Center for Energy Research (Packard) M-11
17 Center for Health Sciences (Chandler-Ullmann Hall) I-10
8 Center for Information and Computer Science (Mart) K-13
31 Center for Marine and Environmental Studies (Williams Hall) H-10
2 Center for Social Research (Figlear) L-15
7 Center for Surface and Coatings Research (Sinclair Laboratory) J-13
19 Computing Center (Packard Laboratory) M-11
19 Energy Research Center (Packard Laboratory) M-11
7 Emulsion Polymers Institute (Sinclair) J-13
13 Fritz Engineering Laboratory I-11
30 Institute for 18th-Century Studies (Linderman Library) J-9
30 Institute for Fracture and Solid Mechanics (Packard Laboratory) M-11
5 Institute for Metal Forming (Whitaker) I-13
17 Institute for Pathobiology (Chandler-Ullmann Hall) I-10
19 Institute of Thermo-Fluid Engineering and Science (Packard Laboratory) M-11
9 Lawrence Henry Gipson Institute for Eighteenth-Century Studies (Maginnes Hall) M-13
32 Materials Research Center (Coxe) I-9
7 National Printing Ink Research Institute (Sinclair Laboratory) J-13
The Wetlands Institute, Stone Harbor, N.J.

Points of Interest

9 Bookstore (ground level, Maginnes Hall) M-13
Dining facilities: Cort Dining Room, Grace Dining Room and The Gallery, all main level west; Snack Bar, second level, south; Asa Packer Room (faculty dining), Sinn Room, Bishop Stevens Room, *et al*, third level; all in the University Center, L-9. The upper level of Rathbone Hall, D-9, affords a dining room with a panoramic view of the Lehigh Valley. Brodhead House will have a dining facility on the main level when it is completed in August, 1979.
9 DuBois Gallery (Maginnes Hall) M-13
19 First Packard automobile, 1899 (Packard) M-19
Flagpole L-10
Freshman quadrangle HI-7
13 Fritz Engineering Laboratory I-11, home of world's second-largest testing machine
Hutchinson Boxwood Collection NO-10
Lower Campus Mall LM-12, 13, 14
Marker denoting location of the first hydraulics laboratory under college auspices in America, established in 1887 under Professor Mansfield Merriman (east of Williams Hall greenhouse) H-9
Nature Preserve GHIJKL-1, 2, 3, 4, 5
18 Packer Memorial Church K-11
Rare Book Collection (Linderman Library) J-9
Reflecting Pool H-11
Sayre Park entrance M-7
Tau Beta Pi bent, I-10, marks founding of national engineering honorary society
Tangle Bank, planned wild vegetation (behind Williams Hall) HI-9
The Lookout (elevation 640 feet) G-6
60 Thornburg House, honors the memory of Dr. Charles L. Thornburg, '25, professor of mathematics and astronomy, whose grandson, Dick Thornburgh, became governor of Pennsylvania in January, 1979 E-9
"Trees," massive sixty-ton, eight-segment steel sculpture by Menashe Kadishman of Israel, located at entrance of Saucon Valley campus
27 Wilson Gallery (Alumni Memorial Building) O-10
University Green LM-10
29 University Center L-9, originally Packer Hall L-9

Residence Halls

201 Brodhead House, high-rise student apartments (completion August, 1979) O-15
55 Beardslee House C-10
Bishopthorpe Residence, Tombler St. and Jeter Ave. (see Bethlehem map)
54 Carothers House C-10
56-62 Centennial I houses D-8
50-55 Centennial II houses B-9
58 Commons area D-9
56 Congdon House C-9
65 Dravo House H-7
64 Drinker House I-7
57 Emery House D-9
62 Leavitt House D-8
67 McClintic-Marshall House L-7
61 McConn House E-8
53 Palmer House C-10
Polk Gardens apartments, 4th and Polk Sts.
66 Richards House G-8
59 Smiley House E-9
52 Stevens House C-10
51 Stoughton House B-10
68 Taylor House M-7
60 Thornburg House E-9
71-77 Trembley Park student apartments N-9
Warren Square Cluster:
196 A, 220-222 Warren Square R-10
192 B, 210-212 Warren Square R-10
24 C, third floor, 532-534 Brodhead Ave. Q-10
193 D, 222-224 Summit St. R-10
50 Williams House B-10

Fraternity Residences

93 Alpha Chi Rho O-4
Alpha Epsilon Pi, 308 W. Packer Ave. T-12
106 Alpha Sigma Phi N-5
99 Alpha Tau Omega I-5
83 Beta Theta Pi N-6
105 Chi Phi O-5
84 Chi Psi P-6
21 Delta Chi, 233 W. Packer Ave. T-12
22 Delta Chi Annex, 230 W. Packer Ave. S-11
86 Delta Phi R-6
20 Delta Sigma Phi, 217 W. Packer Ave. S-11
89 Delta Tau Delta Q-6
81 Delta Upsilon
85 Kappa Alpha R-7
85 Kappa Sigma T-5
97 Lambda Chi Alpha L-4

101 Phi Delta Theta L-6
104 Phi Gamma Delta N-6
88 Phi Kappa Theta S-5
90 Phi Sigma Kappa P-5
Pi Kappa Alpha, 515 Delaware Ave.
98 Pi Lambda Phi K-4
80 Psi Upsilon R-8
94 Sigma Alpha Mu Q-3
102 Sigma Chi M-6
82 Sigma Nu O-7
100 Sigma Phi L-7
92 Sigma Phi Epsilon R-5
25 Tau Epsilon Phi, 227-229 Warren Square
S-11; annex, 216 Warren Square
91 Theta Chi Q-4
107 Theta Delta Chi K-5
96 Theta Xi M-4
95 Zeta Psi K-4

Sorority Residences

The three sororities occupy sections of three buildings in the Saucon student apartments (SMAGS). These buidings are found on the Saucon Valley Campus map.

140 Alpha Phi
137 Alpha Gamma Delta
134 Gamma Phi Beta

Where Education Predates the Nation

Lehigh University shares in the rich historical heritage of Bethlehem, even though, having been founded in 1865, it is a relative newcomer.

The fact that Lehigh was established in Bethlehem reflects in large measure the tradition of education established by the first settlers thirty years before the founding of the nation.

The first Moravians were among the many German religious sects which came to the New World, and especially to Pennsylvania, during the early 1700s. Like William Penn, who established his *sylvania* as a new land where he might hold his Quaker beliefs away from England's oppression, the Moravians also were seeking refuge from persecution.

The early Moravians were industrious. Their first building, the Gemein Haus (community house) was completed in 1741. This fine building still stands today, one of thirty-nine remarkably preserved pre-Revolutionary War buildings constructed by the Moravian settlers. These buildings are located on East Church Street, west of the City Center; industrial buildings are located in the Monocacy Creek valley behind the Hotel Bethlehem.

The leader of the Moravians was Count Nicholas von Zinzendorf of Dresden. He had arrived in the settlement in time for their observance of Christmas Eve in 1741; hence the name Bethlehem.

The settlers built fine structures of stone, demonstrating principles of engineering that were not generally used elsewhere. But their principal interest was music, and they established the first symphony orchestra in America. In 1748, the settlement had a fourteen-man orchestra. The community's first organ was built in 1757 by John Gottlob Klemm. The musical tradition, including the trombone choir, continues today, perhaps most visibly in the Bach Choir of Bethlehem, whose yearly Bach Festival is held in the university's Packer Memorial Church.

Music hath charms... It is said that hostile Indians during the 1750s planned a night attack on one occasion, but the sweet music of hymns emanating into the silence of the night frightened off the invaders, who supposedly thought some godlike power protected the community.

Zinzendorf envisioned Bethlehem as the center for manufacturing; outlying settlements, such as Nazareth, Pa., would be primarily devoted to agriculture. On October 15, 1742, a large barn was "raised" with the help of most of the residents. Three months later a grist mill at the community spring produced the first flour. In 1758, the Sun Inn was built along Main Street, where it still stands today. It was a haven for travelers to the industrial community. The inn is now in the process of restoration.

The Moravians, although avowedly opposed to war, found their community transformed into a hospital when Washington's troops were at Valley Forge during the 1776-78 period. Benjamin Franklin, writing to the governor from Bethlehem, said: "We found this place filled with refugees, the workmen's shops and even cellars being crowded with women and children..." Washington came to the community once, and many other Continental Army officers were visitors.

The Sun Inn was used as a hospital during the Revolutionary War and counted among its patients an aristocratic renegade from France, Marie Joseph Paul Ives Gilbert Motier, the Marquis de la Fayette. Lafayette had come to assist the Continental Army aboard his own ship, the "Victory." Fifty years later a college would be named in his honor.

Zinzendorf's determination that Bethlehem would be a major industrial center was greatly assisted by the completion in 1755 of the water works, the first public utility in the New World. Visitors may view the structure today.

The Moravian dedication to education was an extension of the philosophy of Amos Comenius, who had written, "Everyone ought to receive a universal education." The several Moravian educational institutions which continue today, including Moravian College, stem from this tradition.

The Moravians did not share dialects with the other Pennslyvania Germans. They spoke, as one early observer phrased it, "the most correct German of which America can boast."

The first bridge across the Lehigh River was built in 1794, at cost of $8,000. It was replaced by another bridge in 1816, but the latter was destroyed by a flood in 1841. In 1759, the turnpike (toll road) over South Mountain, generally along the route of the present Wyandotte Street hill, was opened.

"Black gold." During the late 18th century, the presence of anthracite was observed in the Lehigh Valley. In 1818, the Lehigh Coal Company and the Lehigh Navigation Company were formed, one to mine the anthracite on the upper Lehigh, the other to transport it downriver to Philadelphia and other metropolitan markets. Asa Packer and others who would be associated with Lehigh University were prime movers in this effort to transport fuel.

The Lehigh River was difficult to navigate. Consequently, in 1829 the Lehigh Canal was completed from Asa Packer's hometown at Mauch Chunk (now Jim Thorpe) to Easton, passing through Bethlehem. At Easton it connected with the Delaware Canal. During this period Bethlehem was involved in light manufacturing, such as paper box making, combmaking, and trade in musical instruments. There was also a small iron foundry. During the 1840s, iron mines were opened in the area, and several blast furnaces, fueled by the easily accessible coal, were in operation. Zinc ore was found in Upper Saucon Township. These origins eventually led to the steel and zinc production which characterizes the Lehigh Valley today.

The community of Bethlehem has a popuation of approximately 78,000 persons. It is a diverse population with segments from a variety of nations who continue to retain the traditions of the country of their origin.

Bethlehem has two principal employers, Bethlehem Steel Corporation and Lehigh University. The steel company maintains its corporate headquarters in Bethlehem and also has a major manufacturing facility. Its Homer Research Laboratories, costing $50 million and employing approximately eight-hundred persons, is located adjoining the Lehigh campus at the top of South Mountain.

There are five colleges in the Lehigh Valley besides Lehigh, all independent. They are Lafayette, Allentown College of St. Francis de Sales, Moravian, Muhlenberg, and Cedar Crest. A cooperative program is maintained among the colleges. There are also two community colleges in the area.

Registration Statistics

	spring 1977	summer 1977	fall 1977	spring 1978	summer 1978	fall 1978
undergraduates	4024	838	4350	4176	1015	4455
graduate students	1961	1634	1833	1803	1546	1828
special students	10	1	5	6		14
totals	5995	2473	6188	5985	2561	6297

Spring 1977	senior	junior	soph.	fresh.	total
arts and science	218	239	271	244	1072
arts and engineering	11	5	8	22	46
biology	31	17	13		61
business and economics	307	259	222	184	972
chemical engineering	64	72	87		223
chemistry	25	19	9		53
civil engineering	83	91	93		267
electrical engineering	83	75	66		224
engineering		7	62	439	508
engineering mechanics	1	1	1		3
engineering physics	2	5	4		11
environmental science and resource management	13	9	8		30
fundamental science	9	6	4		19
geology	14	8	1		23
industrial engineering	41	53	33		127
mechanical engineering	73	88	110		271
metallurgy and materials engineering	22	12	20		54
psychology	6	3	3		12
total	1003	969	1015	989	4024*

*includes 48 in the General College Division

Fall 1977	senior	junior	soph.	fresh.	total
arts and science	201	224	309	434	1168
arts and engineering	12	6	16	30	64
biology	16	24	21		61
business and economics	264	258	260	200	982
chemical engineering	74	95	92		261
chemistry	19	22	9		50
civil engineering	94	88	65		247
electrical engineering	73	73	113		259
engineering	4	10	54	537	605
engineering mechanics		2	2		4
engineering physics	5	6	12		23
environmental science and resource management	10	8	5		23
fundamental science	8	3	2		13
geology	13	6	3		22
industrial engineering	58	50	59		167
mechanical engineering	91	117	96		304
metallurgy and materials engineering	18	25	16		59
psychology	4	4			8
total	970	1021	1134	1201	4350*

*includes 30 in the General College Division

Spring 1978	senior	junior	soph.	fresh.	total
arts and science	232	226	247	352	1057
arts and engineering	12	4	15	26	57
biology	26	18	25		69
business and economics	291	249	249	205	994
chemical engineering	79	89	76		244
chemistry	25	18	10		53
civil engineering	103	75	54		232
electrical engineering	75	80	91		246
engineering	2	9	75	475	561
engineering mechanics	1	1	2		4
engineering physics	9	8	5		22
environmental science and resource management	10	11	7		28
fundamental science	10	3	1		14
geology	11	6	3		20
industrial engineering	60	53	58		171
mechanical engineering	89	120	90		299
metallurgy and materials engineering	16	30	15		61
psychology	8	2			10
total	1059	1002	1023	1058	4176*

*includes 34 in the General College Division

Fall 1978	senior	junior	soph.	fresh.	total
arts and science	178	222	340	413	1153
arts and engineering	8	18	15	53	94
biochemistry	8	10	3		21
biology	25	18	3	2	48
business and economics	248	276	269	155	948
chemical engineering	99	74	124	5	302
chemistry	19	20	10	1	50
civil engineering	86	64	61	8	219
computer engineering		1	20		21
electrical engineering	70	104	91	5	270
engineering	3	5	60	527	595
engineering mechanics	1	2	1	1	5
engineering physics	6	10	6		22
environmental science and resource management	12	11	1		24
fundamental science	5	4	5		14
geology	10	5			15
geophysics	3		1		4
industrial engineering	52	72	62	6	192
information science		1			1
information and computing science	1	1	2		4
mechanical engineering	110	103	115	10	338
metallurgy and materials science	23	23	20	3	69
psychology	1	1	1	1	4
total	968	1045	1210	1190	4455*

*includes the 42 in the General College Division

Geographical Distribution

All figures are for fall. Only undergraduates are included.

	1977	1978		1977	1978
Alabama	2	1	Australia		1
Alaska		1	Austria		1
Arizona	1	1	Belgium	4	3
Arknasas		2	Brazil		1
California	10	10	Cambodia		1
Colorado	5	4	Canada	3	6
Connecticut	205	208	Chile		2
Delaware	33	44	China		3
District of Columbia	14	13	Colombia	2	3
Florida	19	18	Cuba		1
Georgia	4	4	Czechoslovakia		1
Illinois	20	23	Dominican Republic	1	1
Indiana	2	3	Ecuador	3	3
Iowa	2	3	El Salvador		2
Kentucky	1	1	France	1	
Louisiana	3	2	Germany	3	1
Maine	11	14	Ghana	1	
Maryland	102	113	Greece	3	1
Massachusetts	92	97	Guatemala	1	1
Michigan	10	10	Hong Kong	3	2
Minnesota	4	4	Iran	8	6
Missouri	6	5	Ireland		1
Montana	2	1	Italy		1
Nebraska		1	Japan	1	1
New Hampshire	9	11	Kenya	1	
New Jersey	1147	1189	Korea	1	1
New Mexico	1	1	Lebanon	1	
New York	607	624	Liberia	1	
North Carolina	5	6	Mexico	1	1
Ohio	46	42	Morocco	1	
Oklahoma		1	Pakistan		1
Oregon		1	Panama	1	
Pennsylvania	1857	1954	Peru	2	1
Rhode Island	7	8	Spain	4	2
South Carolina	1	3	Sweden	1	1
Tennessee	2	4	Switzerland	2	
Texas	7	9	Thailand	2	2
Utah		1	Turkey	2	3
Vermont	10	9	United Kingdom		3
Virginia	27	30	Venezuela	1	4
Washington	2		Virgin Islands	3	2
West Virginia		2	totals	4,350	4,455
Wisconsin	5	6			

A fence rail serves as a pry bar while brush is piled under the rear wheels of "Old Pacific" to give it traction in the Iowa mud. The automobile became stuck during the first San Francisco-to-New York transcontinental trip.

II. Admission / Aid / Regulations

The section which follows includes information about admission, advanced placement and financial aid. Subsequent sections relate to what Lehigh offers the student, opportunities for campus participation, and university regulations.

Admission Guidelines

The enrollment of Lehigh University is regulated by action of the board of trustees, with a resulting limitation in the number of candidates who can be admitted each year to the several divisions of the university.

In the selective procedure necessitated by limitation on enrollment, the university, through its office of admission, takes into account a number of criteria which are believed to have some individual validity and in combination a high degree of validity in predicting success in college work.

The material that follows pertains to undergraduates. Graduate students should consult Admission to Graduate Standing, Section IV.

Secondary school preparation. The admission policy of the university is designed to encourage students with varied backgrounds to consider Lehigh while insuring that any individual student is not guided into a program of studies for which he or she is inadequately prepared.

The courses or units required for admission represent the quantitative equivalent of the usual four-year college preparatory program and include certain prescribed subjects for candidates depending upon their college and curriculum choice.

An applicant's full potential as a Lehigh student, including evidence of academic growth and the desire to learn, are special qualities which may not be reflected in mere accumulation of units. Such qualities are taken into consideration.

All applicants should have completed four years of English, two to four years of history and social studies, three years of mathematics and two to four years of laboratory science. Chemistry is required and physics recommended for candidates planning studies in science or engineering.

Students planning to enter the College of Engineering and Physical Sciences or the College of Business and Economics, or the bachelor of science program in the College of Arts and Science, must have studied mathematics through trigonometry.

Students planning a bachelor of arts degree in the College of Arts and Science present upon entrance at least two years of one foreign language. Further foreign language study is strongly encouraged.

One of the major features of Lehigh is the ease with which a student may normally transfer from one curriculum or college to another. Such transferring may, however, necessitate a student's obtaining additional background for the new discipline area on campus or elsewhere.

Minimum subject matter requirements (16 units)

English 4
Foreign Languages* 2
College Preparatory Mathematics** 4
Electives 6

*Only in exceptional cases and for otherwise well-qualified candidates will waivers of the requirement in foreign languages be granted for admission to any one of the three undergraduate colleges.

**Waivers of the requirement in mathematics are granted to otherwise well-qualified candidates for admission who propose to major in one of the following fields offered by the College of Arts and Science: American studies, art and architecture, classics, theater, English, modern foreign languages, government, history, international relations, journalism, music, philosophy, religion studies, social relations, and urban studies.

Note: Chemistry is required and physics is recommended for candidates planning programs in science, arts-engineering, and engineering. Electives should include such college preparatory subjects as languages, social studies, and sciences.

Quality of work. The quality of the candidate's work is more important than merely meeting minimum subject matter requirements.

The strength of his or her preparation is judged primarily by the individual's rank or relative grade in class; by the extent to which the student has made grades distinctly higher than the average grade; by evidence of improvement or deterioration in quality of record as he or she progressed through secondary school; by relative success or failure in the particular subjects which the student proposes to continue in college; and by the comments and recommendations of the principal or headmaster.

Entrance Examinations

All candidates for admission to the freshman class are required to write entrance tests prepared and administered by the College Board. Tests required by Lehigh University are:

Scholastic Aptitude Test. Each candidate is required to write the Scholastic Aptitude Test (SAT) to provide the university with a measure, on a national scale, of aptitude and readiness for college study. The university prefers that this test be written early in the senior year, unless satisfactory junior-year scores were submitted to Lehigh.

Achievement Tests. Each candidate is required to write three additional College Board Achievement Tests. One of these must be English Composition.

Candidates for a science program in the College of Arts and Science or for a program in the College of Engineering and Physical Sciences are expected to write a Mathematics (Level I or Level II) Achievement Test. Candidates for the College of Engineering and Physical Sciences are expected to write a Science (chemistry or physics) Achievement Test.

Candidates for a bachelor of arts program in the College of Arts and Science, including five-year Arts-Engineering candidates, should write an Achievement Test (or Advanced Placement examination) in any foreign language to be studied in college. Whenever possible, the test should be written in high school before entering the university. Other candidates write tests which they may choose in consultation with their advisers. The English Composition and two additional Achievement Tests should be written in the senior year, unless satisfactory junior-year scores were submitted to Lehigh University.

Test information and applications should be secured from the College Board at either of the following addresses (whichever is closer to the candidate's home or school): P.O. Box 592, Princeton, New Jersey 08540 or P.O. Box 1025, Berkeley, California 94701, or from the candidate's school.

Candidates should register for the tests early in the senior year and not later than one month prior to the test date (two months for candidates who will be tested in Europe, Asia, Africa, Central and South America, and Australia).

The candidate is responsible for requesting that the test score be sent to Lehigh University—either by indicating Lehigh in the College Board application or, having failed to do this, by request to the College Board office.

Other Criteria and Interviews

Information about other qualifications of candidates is obtained from principals or headmasters, and counselors. Such information relates to the candidate's health, emotional stability, intellectual motivation, social adjustment, participation in school activities, and established habits of industry and dependability.

Each candidate is encouraged to visit Lehigh University so that he or she may see the university and talk with an officer of admission. An appointment should be made in advance of the visit. Write to Director of Admission, Lehigh University, Alumni Memorial Building #27, Bethlehem, Pa. 18015.

The office of admission is open for interviews every weekday between 9 and 11 A.M. and from 1:30 to 4 P.M. Tours of the campus are available every weekday afternoon, at which time classes are customarily in session. Visitors are welcome during the summer months.

Although a personal interview is not required of all candidates, the university reserves the right to require an interview whenever this appears desirable or necessary and to base determination of admission in part on the report of the interviewing officer.

How to Apply

If a candidate has determined that he or she is sincerely interested in Lehigh University and if the student believes that he or she will meet admission requirements of subject matter and school record, the individual should secure from the office of admission an application for the freshman class.

The application should be submitted early in the last year of preparation for college. Every effort should be made to submit an application during the fall semester of the senior year and definitely not later than March 1 of the spring semester of the senior year.

Application fee. Each undergraduate application for admission to the freshman class or with advanced standing or to the General College Division must be accompanied by an application fee of $25. The check or money order should be made payable to Lehigh University. The application fee is nonrefundable in the event the candidate does not matriculate at Lehigh University. It is not applied toward tuition if the candidate matriculates. An application cannot be accepted without the fee.

Early Decision. Lehigh will give a candidate an early favorable decision on his or her application if the individual meets the following criteria: (1) Preliminary credentials,

including Scholastic Aptitude Test scores, show clear qualification for admission to Lehigh: (2) The person is certain that Lehigh is the first choice of college.

On this basis the committee on admission selects candidates who have submitted requests for early decision by November 1. Lehigh's decisions will be made by December 1. If the decision is favorable, it is assumed the candidate's academic strengths will continue throughout the senior year and that he or she will complete all normal admission requirements. On receiving a favorable decision, the candidate promptly withdraws other applications.

Early-decision candidates whose parents have submitted the Financial Aid Form will receive notice by December 1 of the action taken on requests for financial aid.

The early-decision plan is not appropriate for all candidates. There are many candidates who are unable to make an early college choice. Such candidates are not penalized. Candidates who do not receive favorable replies to their requests for early decision should not feel discouraged. Only a portion of the class is selected under this plan, since the committee on admission prefers to take action on most applications later in the academic year.

Advanced Placement

Lehigh offers able students who have superior preparation an opportunity for advanced placement and/or college credit. Many secondary schools, in association with the College Board, offer college-level work. Students participating in these courses should write the advanced placement tests offered by the College Board.

Entering freshmen who ask the College Board to send their advanced placement test scores to Lehigh are considered for advanced placement. Test scores range from a low of 1 to a high of 5. Those who score 3 or higher may receive advanced placement and/or credit in most departments at Lehigh. Several Lehigh departments offer special examinations to students who studied college-level subjects in secondary school but did not write the advanced placement tests.

Current practice at Lehigh is as follows:

Biology. Three semester hours of credit for Biology 21 are given to those who earn scores of 4 or 5. A test is offered.

Chemistry. Five hours of credit for Chemistry 21 and Chemistry 22 are granted to students who earn scores of 3 or higher, or who score 750 or higher on the chemistry achievement test. A test is offered to freshmen.

English. Advanced placement and six semester hours of Lehigh credit for freshman English are given to students who earn a score of 5. These students need not take the regular freshman English courses, but they are encouraged to elect English 11 and 12, seminars designed to give advanced freshmen practice in reading and writing at the college level. Students who receive a grade of 4 or who have a score of 700 or higher on the verbal section of the Scholastic Aptitude Test receive three hours of credit in freshman English; these students complete the six-hour requirement by taking an English course suggested by the department. Students whose verbal scores are between 650 and 699 and who have received a grade of 3 on the advanced placement test may apply to the department for a special examination which, if completed successfully, will result in three hours of credit and exemption from English 1.

Art and Architecture. Three semester hours of credit are given to those students who earn scores of 3 or higher on the advanced placement history of art exam. Those students who earn scores of 3 or higher on the advanced placement studio art exam also receive three hours of credit.

History. Consideration for credit is given to those who earn 3 on the American History or European History tests. Those students who earn scores of 4 or 5 on the American History test receive eight semester hours of credit; those who earn scores of 4 or 5 on the European History test receive three semester hours of credit. Two special courses, History 51 and 52, are available to those who qualify. A freshman test is offered.

Latin. Students receive three semester hours of credit for a score of 3 or higher on the Virgil examination; those who successfully write examinations in more than one area (e.g. Virgil and lyric poetry) receive six hours of credit.

Mathematics. Four semester hours of credit for Mathematics 21, Analytic Geometry and Calculus I, are granted to those who score 3 or higher on the Calculus AB examination. To those who score 3 or higher on the Calculus BC examination, eight hours of credit are granted for Mathematics 21 and Mathematics 22, Analytic Geometry and Calculus I and II. A freshman test is offered.

Modern Foreign Languages. Advanced placement and three semester hours of credit are granted to students who earn scores of 4 on an Advanced Placement test. Advanced placement and six hours of credit are given to students who earn scores of 5 on an Advanced Placement test. Three semester hours of credit are granted to students who earn scores of 670 to 740 on a College Board modern language achievement test. Those students who earn scores of 750 or higher receive six semester hours of credit.

Music. Three semester hours of credit are given to those students who earn scores of 3 or higher on the advanced placement music theory examination.

Physics. Five hours of credit for Introductory Physics are given for a score of 5 on the Physics B examination or for scores of 3 or higher on the Physics C examination. A test is offered.

International Baccalaureate. Students who earn the International Baccalaureate are granted credit in higher-level subjects in which they earn scores of 4 or higher.

Other Opportunities

The university encourages the initiative which secondary school students are showing in enrolling in advanced courses, in requesting advanced standing in college, and in assuming responsibility for a greater share of their own education.

Besides opportunities for advanced placement of freshmen, sophomores are invited to consider the advantages of enrolling in some junior courses. This may be accomplished by special examinations available in certain courses for students who performed particularly well as freshmen.

In the junior year students may register for interdepartmental honors seminars and in some programs may take "unscheduled work," where they have an opportunity to do individual work in consultation with a member of the faculty. In the senior year students may continue with the interdepartmental honors seminars and may undertake departmental honors programs. Particularly well-qualified students are permitted to take a limited number of graduate courses. Some students engage in research projects in connection with their senior thesis.

The opportunities for able and well-motivated students are increasing each year and more students are qualifying each year for advanced sections and courses and honors programs.

Admission and Deposit

Selection of candidates for the freshman class entering in September is made between the end of February and April 1 following receipt of College Board scores and preliminary secondary school records. Lehigh subscribes to the Candidates' Reply Date, which has been set at May 1.

When a candidate's preliminary credentials are complete and the person has been offered formal admission to Lehigh University, he or she will be asked to notify the director of admission of acceptance of the offer of admission by making a deposit of $50 to hold the place for the student in the limited enrollment. This deposit is not an additional fee but is applied toward tuition charges for the first semester. However, the deposit is forfeited in case of failure to enroll for the specified semester.

Transfer Students

Candidates for admission from other institutions can be admitted with advanced standing to the three colleges of the university. Such candidates must have met the subject matter entrance requirements prescribed for undergraduates at Lehigh. No entrance examinations are required.

A candidate who has studied at another college prior to applying for admission to Lehigh will be considered on the basis of the quality of his or her record at that college. A candidate who has been dropped from another college for disciplinary reasons or for poor scholarship or who is not in good standing at the former college is not eligible for admission to Lehigh.

A student who is planning to transfer to Lehigh should arrange college work so that he or she will cover as many as possible of the subjects of the planned curriculum at Lehigh.

A student who desires to transfer to Lehigh University from another college submits an application for admission (on a transfer form) with a $25 application fee. The student must request each college previously attended to submit to the office of admission at Lehigh University an official transcript of the academic record. Catalog pages describing the courses completed at other colleges should be enclosed with the application. It is not necessary to send complete catalogs.

A candidate who has attended more than one university, college, or junior college must present a record from each institution. Failure to submit a complete record of former academic experience will result in cancellation of admission or registration.

Estimate of Expense For Undergraduates

The current operating costs of Lehigh University are supported principally by three areas of income: tuition and fees, endowment earnings, and gifts and grants. The university is conscious that educational costs are significant and strives to maintain a program of quality while recognizing that there are limitations on what families can afford to pay. The costs will vary somewhat from student to student depending upon the various options chosen.

Summary of Lehigh's Plans

The Tuition Plan. Lehigh provides comprehensive academic and student services under its tuition plan. The tuition sum is inclusive of athletics, health, libraries, student activities, concerts, lectures, and laboratory services. Full-time tuition rate is charged to students enrolled in twelve or more credit hours per semester. For students enrolled in less than twelve semester hours, tuition is charged on a per-credit-hour basis.

The Residence Halls Plan. A variety of living arrangements are available. The university provides housing for 2,200 students on the campus in a wide selection of housing facilities. The housing arrangements are grouped within three basic categories, with rates associated with the category level. Most residence halls contain rooms designed for double occupancy; however, a limited number of single, triple, suite, and apartment units are available. In order to guarantee a space within a residence halls unit, a $100 deposit is required for each semester. This deposit is credited toward the room charge for the respective semester.

The Board Plan. The food service operation at Lehigh is unique for a campus its size in that six board plans are available. The basic 21-meal-per-week plan is required of all freshmen residing at Lehigh. Upperclass students living in regular residence halls units have the option of participating in any of the plans providing ten or more meals per week. Students residing in fraternities, sororities, campus apartments or off-campus facilities are eligible to participate in any of the board plans.

Charges and Fees for 1979-80

All charges and fees are due two weeks prior to the start of classes each semester. On a per-term basis, the expenses are charged at one-half the per-year charge. Accounts not settled by the due date will be subject to a late-payment fee.

Tuition and Fees for 1979-80

Tuition	$4,550
Residence Halls	
Category I (Dravo, Drinker, Richards, McClintic-Marshall, and Taylor houses; Warren Square Cluster; Bishopthorpe Residence; and Polk Gardens apartments)	960
Category II (Centennial Houses I & II)	1,040
Category III (Trembley Park & Brodhead House)	1,100
Board	
Plan A (21 meals per week)	940
Plan B (17 meals—Monday breakfast through Saturday lunch)	890
Plan C (15 meals—Monday breakfast through Friday dinner)	860
Plan D (10 meals—lunch and dinner Monday through Friday)	830

Based upon the above charges, a freshman would normally be billed the tuition rate along with the Category I room fee and the Plan A food plan. The total cost for the three areas would be $6,430 for the year.

Miscellaneous and Special Fees

All references are to charges per semester.

Per-credit-hour tuition charge for part-time students	$190
Listener fee, per course	190
Board Plan E (five lunches per week)	155
Board Plan F (five dinners per week)	275
Orientation Board Plan (freshmen only)	30
Late registration	20
Late payment of fees	20
Installment plan	15
Late installment payment	20
Application fee (for admission consideration)	25
Pre-registration revision	10
Late pre-registration	20
Change of roster	10
Examination make-up	5
Transcripts (no charge for first one)	1
Late application for degree	20

The university reserves the right at any time to amend or add charges and fees as appropriate to meet current requirements. Fees applicable to the 1980-81 academic year will be announced no later than January, 1980.

Other Expenses

A student should plan upon meeting various other expenses. These expenses include the purchase of books and supplies from the university's bookstore located in Maginnes Hall. Necessary purchases supporting one's academic program should average $200 per year. The bookstore carries a complete line of basic goods for student needs. A student should also allow for an allowance to handle personal and travel expenses.

Plan of Payments

An itemized statement of charges is mailed from the bursar's office approximately six weeks prior to the start of each semester. Payment is expected in full by the specified due date. Payment plans are available for those desiring extended payment arrangements.

Persons desiring a payment plan can elect participation in either the Girard Trust Edu-Check Plan or the Richard C. Knight Tuition Plan. Complete information is available from the bursar's office. Those persons desiring to use one of the plans must complete the necessary details no later than two weeks prior to the due date for payment. The university is also able to offer a plan which requires that 60 percent of the statement be paid on the due date with 20 percent due one month after registration, and 20 percent due two months after registration. A fee is charged for this service.

Students attending the university under a provision with a State Board of Assistance or with financial aid from other outside agencies must supply complete information to the bursar's office if assistance is to be recognized on the semester statement.

Refund of Charges

A student in good standing is entitled to a voluntary withdrawal from the university. Refunds on tuition are based upon the official date of withdrawal as established by the registrar. The refunded amount is the tuition sum paid less $100 and less a deduction of two percent of the tuition for each day of instruction completed. In the event of an untimely death of a student, tuition will be refunded in proportion to the remaining semester. Any student suspended or expelled from the university will not be granted a tuition refund.

Residence hall rooms are rented on an annual basis only. Refunds are made in full in the event a student does not register because of illness, injury, death, or is dropped from the university due to academic reasons. Partial refunds during the year are possible only in the event of a voluntary withdrawal and with the provision that the student can transfer the lease to another student for whom no other accommodations exist. Any student suspended or expelled from the university is not entitled to a room refund.

Board refunds are based upon the number of unused days remaining in the board plan. Refunds are granted based upon voluntary withdrawal, illness, or death. Pro-rated refunds on board charges are based upon the date the meal card is returned to the office of residence operations.

Campus Accommodations

Approximately eighty percent of all undergraduate men and women are in residence in university-operated facilities. These take the form of residence halls, garden apartments, apartments in a multi-story building, or residence in fraternity houses or sorority units. Some students choose from a limited number of university-operated facilities located near the campus or in the community.

Residence Halls

More than half of Lehigh undergraduates live in university residence halls. Lehigh has twelve principal residence halls for undergraduate men and women. Most rooms are designed for two students, but a limited number of single, triple, or suite arrangements, and apartment units are available.

When a candidate accepts an offer of admission to the freshman class, the candidate is sent a Room and Board Application-Contract. Those desiring accommodations in the residence halls must return this application-contract promptly. Priority of assignment is based on date of receipt of this application. A nonrefundable advance deposit of $100 must accompany the application. The deposit will be credited to the fall semester room and board charges. Normally, freshman room assignments are made in early August by the residence operations office.

Currently, the demand for upperclass campus housing exceeds the supply by approximately ten percent. For the duration of this imbalance, the University Forum has approved the use of in-class lotteries to provide for fair and equitable distribution of available housing among upperclass students. Lotteries are scheduled early in the spring semester. Those students who are guaranteed housing pay a $100 deposit to hold the space for the following academic year.

Each student in the traditional residence halls is provided with a bed, mattress, chest of drawers, desk and chair. Residents supply such personal items as pillows, waste-baskets, quilts, ashtrays, and radios. Most residents supply their own desk lamp. Students may supply their own bed linen and towels and make their own arrangements to have these laundered, or they may subscribe to a linen service which provides clean bed linen and towels each week. A coin-operated laundry service for student use is available in close proximity to each residence hall.

Residents are held responsible for damage done to their

rooms or any other part of the residence halls.

The university is not responsible for the loss or destruction of any student property whether such losses occur in the residence halls, lockers, classrooms, etc. The safekeeping of student property is the responsibility of each individual student and no reimbursement from the university can be expected for the loss of such property. Insurance protection, if desired, may be obtained by a student or his or her parents from an insurance broker or agent.

Information on off-campus housing may be secured from the residence operations office.

Social Fraternities and Sororities

Approximately one-third of the male students live in fraternity houses. Such accommodations are available to upperclassmen who receive invitations to join the groups.

Three national sororities were recognized by the university in 1975. They are Alpha Gamma Delta, Alpha Phi and Gamma Phi Beta. Each sorority operates its own house in the Saucon Valley housing complex.

Of the thirty-two social fraternities with chapters at Lehigh, twenty-seven occupy houses on the campus. The remaining houses are in Bethlehem near the campus. Freshman are "rushed" during the first semester of the freshman year, but they do not move into fraternity houses until the sophomore year.

Many commodities and services needed by the fraternities are provided by the cooperative Fraternity Management Association (FMA). Students who accept invitations to live in fraternities are required to formalize their acceptance in a written contract with the fraternity. These contracts are based on budgets prepared with the FMA and approved by the fraternity chapters and alumni corporations. These contracts are binding in the fraternity segment of the university's residential system. Accordingly, upon registration for the academic period covered by contract, fraternity members are obligated to pay approved fraternity bills through the university.

Living costs in fraternities vary with the individual chapters but are generally of the same order of expense as residence (room and board) in university-operated halls.

Fraternities, all nationally affiliated, include the following: Alpha Chi Rho, Alpha Epsilon Pi, Alpha Sigma Phi, Alpha Tau Omega, Beta Theta Pi, Chi Phi, Chi Psi, Delta Chi, Delta Phi, Delta Sigma Phi, Delta Tau Delta, Delta Upsilon, Kappa Alpha, Kappa Sigma, Lambda Chi Alpha, Phi Delta Theta, Phi Gamma Delta, Phi Kappa Theta, Phi Sigma Kappa, Pi Kappa Alpha, Pi Lambda Phi, Psi Upsilon, Sigma Alpha Mu, Sigma Chi, Sigma Nu, Sigma Phi, Sigma Phi Epsilon, Tau Epsilon Phi, Theta Chi, Theta Delta Chi, Theta Xi and Zeta Psi.

Financial Aid

The university offers financial aid opportunities to needy and promising students who otherwise would not be able to attend. Approximately thirty percent of undergraduates receive aid from the university, and many more apply for aid.

During 1978-79, 320 of 1,076 men and women in the freshman class received Lehigh aid. Some 2,330 aid applications were received. Offers of financial aid were made to 686 applicants. In addition to the 320 freshmen who received Lehigh aid funds, approximately 100 received aid from sources independent of the university such as ROTC scholarships, awards from parents' employers, and guaranty student loans.

Philosophically, Lehigh expects that all families of its students will make every effort to pay the tuition charges and other costs of attendance. Lehigh's aid program attempts to provide the dollar difference between the cost of attendance and the amount of money the family can contribute toward that cost. This gap is called financial need. Virtually all financial assistance, from whatever source, is awarded on the basis of need.

There are four basic forms of financial aid: scholarships, grants, loans, and student employment. *Scholarships* are based on academic achievement and need not be repaid; most have financial need as a criterion for eligibility. *Grants* are based on financial need and do not require repayment. *Loans* are borrowed money and are repayable at low interest rates after the student ceases to be enrolled. *Employment* provides money for books and personal expenses, with funds disbursed as the student earns them at an hourly rate. Lehigh offers all four forms of aid.

Additional sources of aid are the Federal Government, state agencies, and various clubs, churches, fraternal organizations, and foundations. High school guidance counselors may be able to provide information on local aid programs. Lehigh expects students to be enterprising enough to seek out and apply for all possible kinds of outside financial assistance. The federal Basic Educational Opportunity Grant program and state grant programs are important sources of such aid. If students take maximum advantage of outside sources, Lehigh aid funds can be spread further and student borrowing can be kept to a reasonable level.

Application Procedures

Families desiring financial aid for a prospective freshman file a Financial Aid Form (*FAF*) with the College Scholarship Service (*CSS*) by January 31 of the student's senior year in high school or preparatory school. Forms are available in guidance offices in November.

All applicants should request that CSS send a copy of the FAF to Lehigh. (The Lehigh code number is 2365.) Applicants also should have CSS send copies to both the federal Basic Educational Opportunity Grant program and the state scholarship agency, if the student's home state has such an agency. If the student is granted aid from Lehigh, a notarized copy of the parents' most recent federal income tax return, Form 1040 with schedules, must accompany the acceptance. Aid awards are not final until the FAF and Form 1040 are cross-checked. Award adjustments are made where difference in income and assets exists.

No other aid application is required for incoming freshmen. The submission of the Financial Aid Form establishes the student as an applicant for all forms of Lehigh aid as well as federal aid awarded by Lehigh—Supplemental Educational Opportunity Grants, National Direct Student Loans, and College Work-Study jobs. Students should not request a particular type of grant. Although Basic Educational Opportunity Grants can be used to attend Lehigh, the grants are awarded directly to the student by the Federal Government; Lehigh does not make the award. This is why those desiring aid must request that the College Scholarship Service send the Financial Aid Form to the BEOG program, listing Lehigh (code 2365) as a college of record.

Normally, the committee on undergraduate financial aid makes first selections in March and notifies candidates as promptly as possible. The committee endeavors to aid as many well-qualified students as funds will allow. In the competition for aid funds, need is the primary criterion, but exceptional academic achievement and promise, commendable participation in activities outside the classroom, and good citizenship are also considered. More students have been

aided since the advent of the "package" concept of award-making in which a student receives a combination of nonrepayable aid (scholarship or grant) and self-help (loan and employment).

Applications for admission are reviewed without regard to whether or not the applicant desires financial aid. A needy applicant may receive favorable consideration for admission but not receive university aid. Even students who do not receive university aid are being subsidized because, at an independent institution like Lehigh, tuition covers only a part of the cost of operating the university. Remaining expense is met by income from endowment funds and through gifts and grants from alumni, friends, corporations, and foundations.

Renewal of Financial Aid

It is necessary to reapply for financial aid each year. Application forms are distributed and proper filing procedures explained at several large-scale meetings each February. All students are notified of the meetings, and prospective aid applicants must arrange to attend.

Upperclassmen file the Financial Aid Form with the College Scholarship Service by April 1. A Lehigh application form must also be completed and returned to the university's financial aid office, accompanied by a signed copy of the parents' 1978 federal income tax return. An upperclassman is precluded from aid until the FAF, Lehigh application and parents' 1040 income tax forms are on file.

In addition, to receive any type of aid, a student must make normal academic progress each year by completing at least 24 hours of new course work. Recipients of Lehigh grants and scholarships are expected to achieve at least the level of the all-university average (2.6).

Notifications of eligibility are made by July 1 for applications filed on time.

Transfers. Each year a number of transfer applications are awarded aid, as funds permit. Filing requirements are the same as for renewals, with the additional requirement of a *Financial Aid Transfer Record*. This form is mailed directly to the student at the time of filing an admission application, and must be completed by each college or university previously attended. Notifications are usually made in late May, assuming all forms are on file and an offer of admission has been made. All aid applicants are required to file for a BEOG and state grants, if available.

Costs of Attending Lehigh

The approximate cost of attending Lehigh during 1978-79 was as follows. Figures for 1979-80 are found on page 21.

	resident/off-campus	commuter
tuition	$4,130	$1,130
room and board	1,870[1]	620[1]
books	200	200
miscellaneous	500[2]	750[2]
	$6,700	$5,700

[1]The room and board figure is based on double occupancy in one of the more recently built residence halls, with the 21-meal-per-week plan required of freshmen living at Lehigh. For commuters, the figure represents a possible cost of living at home.
[2]The "miscellaneous" figure covers a weekly allowance for personal needs and the cost of health insurance and linen service. For commuters it also covers transportation and campus meals.

These figures are as realistic as Lehigh can make them. For the 1979-80 academic year, tuition increased $420, and students entering in the fall of 1980 and thereafter would be well advised to plan for larger expenditures.

Guidelines for Aid

Because of the expense of higher education, many families find it desirable to assess the financial realities. The following may be useful.

A student's eligibility for financial aid is determined by analyzing the amount a family can be expected to contribute based on income, assets, family size, number in college, availability of social security or veterans benefits, and other factors. The expected contribution is then subtracted from the cost of attendance to yield the financial needs figure.

A student's savings and expectation of summer earnings are considered part of the family contribution. Incoming freshmen are expected to contribute $600 from summer earnings. Rising sophomores, juniors and seniors are expected to contribute $700, $800 and $900, respectively. Higher contributions may be expected from students who have exceptional summer employment opportunities.

A student might be expected to have some financial need when a family including both parents has an annual income of and number of tax dependents (children) as follows:

$26,000 with one child at home
$29,000 with two children at home
$32,000 with three children at home
$35,000 with four children at home

In all cases the figure is for income before taxes and deductions, allowing for normal savings and home equity. The above figures are for families with one child attending college. When more than one child is in college, the likelihood of a determination of need for financial aid is increased. In some instances, families with incomes as high as $45,000 are able to establish financial need if, for example, they have three children, all of whom are enrolled in independent colleges like Lehigh.

Help From the University

Several forms of university-funded assistance, based on need and merit, are available to Lehigh undergraduates.

Trustee scholarships are awarded covering the tuition charges in whole or in part. These funds are budgeted from general university income.

Supported scholarships are provided by individuals, foundations and corporations through annual contributions.

Endowed scholarships are those funded by income from investments designated for this purpose. Lehigh has 140 such funds, half of which are for general, unrestricted use. Most of the others are restricted by curriculum or geographic location—specifying that the student be enrolled in a specific major subject, or that the student come from a particular area.

Merit scholarships are financed through the Annual Fund, to which alumni, friends and parents make contributions. The National Merit Scholarship Corporation conducts the competition. Merit finalists listing Lehigh as their first choice will be considered. The individual stipend is based on need, and is adjusted annually according to the financial status of the family and the student's ability to earn funds during vacation periods. Stipends range from a $500 honorary award to $1,500 per year. Up to thirty four-year scholarships may be awarded annually to entering freshmen.

Athletic awards place more emphasis on nonacademic attainments. Alumni Student Grants, also supported by the Annual Fund, are awarded on the basis of need to students who have demonstrated aptitude and achievement in athletics.

Presidential prizes are awarded annually to ten incoming freshmen. The $4,000 prizes are granted irrespective of need. A sum of $500 is applicable each semester toward tuition costs. Students receiving these prizes maintain a B (3.0) average or better for continuation of the award.

Lehigh loans are made on the basis of need and merit. The maximum indebtedness that any student may incur generally does not exceed half the total tuition obligation. Each student qualifying for a loan signs a note, endorsed by his or her parents. Repayment is made in minimum monthly installments of $50 beginning three months after graduation or withdrawal, until the loan plus interest is repaid. Repayment schedules are arranged by the Lehigh bursar's office. Currently, loans bear interest at the rate of 4% from the date of the note, with provision that the rate increases to 6% if a note falls into default.

Tuition Installment Plan

Through the *tuition installment plan*, the university makes possible the spread of tuition and other charges in three payments, as follows: 60% of the total semester charge in August, 20% on or before September 30, and 20% on or before October 30. A service charge of $3 is assessed. A similar plan is available in the spring.

Availability of Jobs

The financial aid office coordinates the placement of students who have received aid in the form of a work-study job. Those selected who desire to work should stop by the office as soon as they know their academic schedules and look over the job list.

As a supplementary service, the office posts all on-campus and off-campus jobs of which it is notified. These jobs are open to all interested students, but students must take the initiative in applying for them. The university libraries, the athletic and intramurals departments, residence halls operations, the dining service, and many other campus offices employ students part-time.

Aid recipients are cautioned that if they do not receive a job as part of their aid package, they probably cannot earn more than $100 in an outside job without becoming "over-awarded"—meaning that the sum of all resources exceeds computed need. "Over-award" status can jeopardize other portions of a student's aid package.

Help From Federal Sources

Students who are U.S. citizens and who apply for Lehigh-funded aid will be screened automatically by the university for three aid programs sponsored by the U.S. Office of Education.

Each year Lehigh applies for funding for these programs and the number of possible awards is determined by the amount of money the Federal Government grants to Lehigh.

Supplemental Educational Opportunity Grants. The *SEOG* program is designed for students of exceptional financial need. Grants ranging from $200 to $1,500 per annum are available for four years of undergraduate study. *SEOG* awards may not exceed $4,000 for four years.

National Direct Student Loans. The *NDSL* program enables the university to lend up to $1,500 per year, or $5,000 for four years. Repayment begins nine months after graduation or withdrawal, with minimum quarterly payments of $90. Up to ten years may be allowed to pay back the loan. During the repayment period, 3% interest is charged on the unpaid balance of the loan principal. No payments are required for up to three years while serving in the U.S. armed forces, the Peace Corps, or Volunteers in Service to America (VISTA). The financial aid office can explain loan cancellation provisions which affect some borrowers who become teachers.

College Work-Study. The *CW-S* program assists students by subsidizing the wages they earn in campus jobs. Participating students may work up to twenty hours per week during the academic year and up to forty hours during vacation periods.

Other Governmental Assistance

Several other forms of financial assistance are available from federal and state sources. Among them are the following:

Basic Educational Opportunity Grant. Students apply directly to the Federal Government for the *BEOG* program. It provides nonrepayable aid. *BEOG* awards for the 1979-80 academic year will range from $200 to $1,800. To apply, a student may either request that information from the family's Financial Aid Form be sent by the College Scholarship Service to Basic Grant or the student may fill out a separate *BEOG* application. The former procedure is simpler because Lehigh requires the filing of the form anyway.

A Supplemental Form (available from the university) may be used for major changes in family circumstances such as the death, disability or loss of employment for ten weeks or more of a parent, or for separation or divorce of parents.

State grant programs. Several states offer financial help to students who apply directly to the state for aid. High school guidance offices can provide information on application procedures. Some states, notably New York, do not allow state grants to be used in other states.

Students living in Pennsylvania may be eligible for a grant-in-aid, ranging up to $1,500. New Jersey residents may receive $500. Lehigh students also have received grants from Connecticut, Massachusetts, Ohio and Rhode Island.

Lehigh expects students to apply for state grants so that the needs of more students can be met. Failure to apply for state aid could jeopardize a student's eligibility for renewal of Lehigh aid.

Guaranteed Student Loans. The *GSL* programs exist in most states and allow students to borrow between $1,000 and $2,500 annually up to a maximum of $7,500 for undergraduate study. The student makes application to a participating bank or lending institution. Loans are repayable in monthly installments commencing nine months after the student ends study at least half-time. Interest is 7% per annum and is federally subsidized up to the start of repayment for all borrowers after November, 1978. Borrowers do not have to make payments for up to three years while serving in the Armed Forces, Peace Corps, or in full-time volunteer programs conducted by ACTION. In addition, deferment is available any time the borrower returns to full-time study in approved programs. A single deferment for a period of not more than one year is also provided for students who are unable to find fulltime employment.

Lehigh recommends the *GSL* as part of most aid packages, reserving National Direct Student Loans and university tuition loans for those not able to find a lender. It is a university policy that a guaranty loan, if added to a National

Direct Student Loan, cannot result in a combined one-year indebtedness in excess of $2,500.

Many families not qualifying for aid based on need have used the *GSL* to ease their cash-flow problems, especially because of its low interest and deferred repayment characteristics. A Guaranteed Student Loan, together with the Lehigh *tuition installment plan* has lightened the burden for many families.

Checklist for Financial Aid

There are numerous steps involved in obtaining financial aid. The following checklist is provided in the hope that it will prove helpful to those desiring financial aid. The section which follows applies, except as noted, to incoming freshmen and to students transferring to Lehigh undergraduate programs from other colleges and universities.

1. (freshmen only) Take the Scholastic Aptitude Test (SAT) required of every entering freshman for admission and for financial aid selection.

2. Submit an application for admission. Aid requests will not be reviewed until admission decisions are made.

3. (transfers only) Submit the *Application for Undergraduate Financial Aid.* Be sure to complete all questions and have your signature on the affidavit notarized. Also, have your previous college(s) complete and forward the *Financial Aid Transfer Record.*

4. Submit the *Financial Aid Form* available from high schools and colleges. The form should be completed by parents and applicant and submitted to the College Scholarship Service. List Lehigh University, CSS *code 2365*, in items 81 and 83 to ensure both university and Basic Educational Opportunity Grant consideration.

5. Submit a state grant application, particularly if you are a resident of Pennsylvania, New Jersey, Ohio, Massachusetts, Connecticut, Rhode Island, Maryland, Delaware or Vermont.

6. Submit signed copies of the latest IRS form 1040, with schedules, filed by student and parents. The 1978 tax return is required for the 1979-80 academic year, while the 1979 return will be required for consideration of financial aid in the 1980-81 academic year.

7. Double check to be sure your social security number is listed on all forms and on your application for admission.

For Enrolled Students

1. Submit to the Lehigh office of financial aid the application for undergraduate financial aid by April 1 preceding the fall semester in which you desire aid. The application and other required forms will be distributed during February.

2. Follow all but the first three steps in the Checklist.

Services, Assistance And Resources

The Lehigh administration adheres to the philosophy that a student who finds pleasure in the university experience has the best likelihood of success in academic endeavors. Further, Lehigh seeks to foster the personal, as well as the academic development of students through residential life, sports and activities.

In paragraphs which follow, services provided by Lehigh for its students are described. Of course, it is incumbent upon the individual student to use the services and facilities which have been provided and to participate in activities. The Lehigh student, it is assumed, is a self-reliant individual who chooses to pursue a rounded educational experience while recognizing the primary academic objectives.

There are also musical programs, programs which bring speakers of interest to the campus, and Lehigh's form of student participation in governance which offers opportunities for those interested in the decision-making process.

Guidance and Assistance

General counseling of individual students, especially in the freshman year, begins with the residence halls counselors, who are known as Gryphons. These counselors are carefully selected upperclassmen who help the first-year students and who direct them to more highly specialized aid when needed.

Freshmen whose problems transcend the competence of the residence halls counselors come to other advisers for guidance in many areas of student life and welfare. Problems of vocational choice and academic adjustment are not uncommon, particularly during the freshman and sophomore years. At all levels, academic and procedural questions, personal problems, social adjustment difficulties, and many other troubles are dealt with daily.

The office of the dean of students serves as a central agency in helping students to meet their problems and concerns, both through its staff and through referral to other student personnel and academic offices. Members of the dean's staff interview each freshman individually during the first year.

Each student in the College of Arts and Science is assigned a freshman adviser with whom the student discusses academic interests prior to registration. The choice of studies is carefully organized in terms of specific backgrounds of preparation and future objectives. Individual counseling continues throughout the student's four years in the college.

In the College of Business and Economics, faculty advisers work with the student concerning his or her individual problems for the same purposes. Similarly, an associate dean of the College of Engineering and Physical Sciences spends much time with the freshman engineering students in an effort to help in the adjustment of academic difficulties and in better definition of vocational objectives. These forms of advisement are carried on through the following years with the student's academic advisers.

A student's problems often require more specialized attention, whereupon the student is referred to the particular service which should be consulted. Problems of mental or physical well-being are, of course, referred to the university health service. The university chaplain is available for the student with religious, moral, or personal concerns that are interfering with his or her peace of mind and studies. A Roman Catholic chaplain also is in residence and available for counseling. A local rabbi serves as spiritual adviser to Hillel Foundation members.

If a student is uncertain about vocational plans or needs to know more about his or her own capacities, interests or personal characteristics, the university counseling service is available without charge. Confidential interviews may be secured by any student who wishes to review his or her own progress and further evaluate and refine his or her thinking about future goals. Services offered include personal counseling for those students who may need and desire it. The counseling service works with the health service in matters of mental health.

Later, in the senior year, the question of prime importance is the decision on a position after graduation. The director of placement services, in personal and group conferences, advises on applying for a position, on being interviewed, and on the relative advantages and disadvantages in working for the different business and industrial firms and other employers seeking the services of college graduates.

Financial problems can become a serious hazard for a student. The director of financial aid is available for consultation on these problems.

If a student is a veteran of military service and has questions involving relations with the Veterans Administration, he or she should contact the registrar. The registrar also is an adviser on military service, on matters of transferred credits, graduation requirements, and allied topics.

A serious hazard to success in a student's academic life may be in poor study habits or reading skills. The Learning Center can provide help.

Students with legal problems should consult the office of the dean of students for direction concerning legal counsel.

Not all student problems are individual problems. Many are group problems, having to do with group living in the residence halls, with student activities, student organizations of many kinds, fraternity and sorority life, and campus social life in general. The deans and their assistants give much time to these areas of student life.

Many members of the teaching faculty are deeply interested in students and student life and spend a great deal of time working with student groups. They contribute their services as academic advisers, activity sponsors, group sponsors and advisers, by entertaining in their homes, and in friendly personal relationships with students.

In these and in other ways Lehigh University endeavors to maintain the close contacts with students which characterize the smaller institution. Services are available for all student needs, and the student need only turn to his or her nearest residence hall counselor, professor, or closest campus friend to learn where help can be obtained.

Student Health Service

The services of the university health center are available to the entire student population—undergraduate and graduate, full and part-time, resident and commuting students. Emergency care is available to staff and faculty.

The health center, located in Johnson Hall, has the following clinic hours:

fall and spring terms
9 A.M. to 6 P.M., Monday through Friday
9:30 A.M. to noon Saturday

During vacation periods and summer
8:30 A.M. to noon, 1 P.M. to 5 P.M. Monday through Friday
No Saturday clinic hours

Outpatient department. The outpatient department includes the medical clinic, minor surgical clinic, allergy clinic, and gynecological service. The emergency room, staffed by registered nurses with physicians on call, is open twenty-four hours daily during the school year.

Hospital unit. Inpatient care is available for all students eligible to use the health center. Registered nurses are in attendance with a physician on call at all times. No major surgery is performed at the health center. Critically ill cases are usually transferred to a general hospital.

Physical therapy. A registered therapist is employed.

Clinical studies. Laboratory tests are made in the center, with the technician in attendance from 8:30 A.M. to noon daily.

Physical examinations. These are required prior to a student's arrival on campus. Following enrollment, additional examinations are provided by the health center for students participating in intercollegiate athletic programs, and when required for graduate school or scholarship programs. The health service does not provide examinations for military, insurance or employment purposes.

Costs. There is no charge for most of the care provided by the health service. This includes both in-patient and out-patient care. Some exceptions are as follows: referrals to physicians, hospitals, or other medical facilities outside the student health center, medications not carried by the health center and for which prescriptions need to be given, and certain biologicals, such as flu vaccine.

Insurance. A low-cost insurance plan providing a full year's comprehensive coverage is available. The plan provides for $1,000 coverage for each accident or illness. Expenses covered include hospital bills, medical fees, X-rays, laboratory studies, and medications. Major medical provisions offer payment of up to eighty percent of expenses in excess of $1,000, up to a maximum of $5,000. Students are urged to check with their parents regarding existing insurance coverage, and to consider purchasing the university-sponsored plan if they are not adequately covered. This insurance coverage is available to graduate students, but individual application must be made via the bursar.

The brochure. A health center brochure is distributed to all entering freshmen and is available through the health center to all other students. This brochure describes in more detail the policies and program of the health service.

Counseling Service

The counseling service, located in Johnson Hall, offers the opportunity for consultation with clinical psychologists and other counselors in regard to a wide variety of problems ranging from those concerns that arise during the course of normal development to more debilitating emotional disturbances.

In cases where pertinent and objective information concerning academic ability, vocational interest or social-personal adjustment is desirable, psychological tests are often administered. Such test batteries are available at every student's individual option. Interpretation of these tests is intended to help the student achieve maximum effectiveness in course work and studying, professional development and campus life. The test scores are utilized as only one of a number of sources of information important to wise and effective planning. Where appropriate, cross-communication with other university advisers is undertaken in gathering together information and expediting plans made cooperatively with the student.

A career information library is maintained by the counseling service, to which students can refer as they attempt to develop a clear conception of the educational and vocational world and their place in it. Objective data concerning educational and occupational opportunities are important factors in effective decision-making skills.

When a student is generally uncertain, confused and unable to plan for the future with confidence, he or she may undertake personal counseling aimed at helping the

individual understand his or her direction and motivation.

Psychotherapeutic counseling, in particular, encourages the student to explore the sources of his or her feelings, to consider their influence on behavior and to discover new ways to manage one's own affairs more effectively. Personal psychotherapeutic interviews would be intense and likely to involve conferences over an extended period of time.

Both testing and counseling services are available, without cost, to all university students and all interviews are held in confidence.

Although student counseling is its major professional activity, the counseling service is also the administrative center for a variety of local and national testing programs in which students might wish to participate during their college career. The most frequently administered of these programs are the Graduate Record Examination, Law School Admission Test, Graduate Management Admission Test and the Miller Analogies Test.

The service also engages in research on tests, counseling and other functions. The results of such research are ultimately useful in the counseling of individual students.

The Learning Center

The performance of college students is influenced by many things, not the least of which is the mastery of those skills necessary for academic success. High-level skills are needed in preparing assignments, note-taking, outlining, listening, recalling information, taking examinations, preparing oral and written reports, and keeping up with a prodigious amount of critical and comprehensive reading.

At Lehigh, a campus noted for its highly motivated student body and strenuous academic program, more than five percent of all university students, both graduate and undergraduate, consistently utilize the services of The Learning Center. Established in the fall of 1977, it provides a schedule of tutorials, seminars, workshops, review sessions, and special academic support services for all Lehigh students during the year. Through a program of faculty referrals, periodic notices to the student body, and a continuing schedule of student-based offerings, the center helps students to improve specific communication and computation skills, maintain acceptable performance levels, and increase their academic standing according to individual needs. A high degree of individualized assistance is emphasized.

Under the aegis of the department of English, The Learning Center provides Lehigh students with a continuing opportunity for academic improvement through personalized instruction by professors, graduate teaching assistants, a technical staff, and a program of services that includes a language learning laboratory, a computer console with complete access to the university's programming, and a wide variety of audio-visual materials. The center is located on the top floor of Coppee Hall.

Placement Services

The university provides centralized placement services for engineering and physical sciences, business and economics, and arts and science seniors, graduate students, and alumni seeking to meet their postgraduate plans.

Among the objectives of placement services, located in Christmas-Saucon Hall, is to help students learn the dynamics of the investigative and decision-making processes involved with postgraduate plans. An additional objective is to help students and alumni learn how to seek, interpret, and integrate career and occupational information into their interests, objectives and goals.

Each year, several hundred representatives from business and industry come to Lehigh. In addition to on-campus interviews, many employers seek candidates by direct referral. The placement services staff helps to arrange interviews for prospective employers by means of a system of information flow between employer and student. In addition, the staff serves as a resource for students and alumni as they develop professional goals and career plans. Current occupational information and assistance for students seeking summer employment also are provided.

Library Resources

University library resources, representing more than 670,000 volumes, are housed in two buildings.

Linderman Library contains 530,000 volumes in the humanities and social sciences, as well as the rare book collection of approximately 6,000 volumes. The structure is comprised of the semicircular edifice designed by Addison Hutton and built in 1878, and a Gothic addition built in 1929.

Mart Science and Engineering Library, a contemporary structure, honors father-and-son alumni Leon and Thomas Mart and houses 135,000 volumes in the natural and physical sciences, mathematics, and engineering.

The Linderman collection reflects academic strengths in British colonial history, and English and American literature. The library also serves as a depository for federal and Pennsylvania state governmental documents and United Nations publications. Important original editions in the history of science, the Renaissance, and in American literature are among the treasures preserved in the university rare book and Robert B. Honeyman collections.

The media center is a recently established dimension of the university library system. The facilities and staff, located in Linderman Library, provide services for producing and purchasing nonprint materials, as well as access areas for group and individual viewing.

In addition to its strengths in engineering and the sciences, Mart Library also houses the international Wiswesser Line Notation File, a collection of publications related to the development of this method of chemical formula notation. An all-night study room is available to students in Mart.

The libraries receive more than 7,500 periodicals and serials, including foreign and domestic newspapers. The collection is accessible to faculty and students in open stacks. Circulation and other facets of library operations are automated. Resources of the library system are augmented by membership with the Lehigh Valley Association of Independent Colleges, the Center for Research Libraries, and the Ohio College Library Center.

The university library staff is dedicated to a service-oriented philosophy and to the provision of programs which stimulate the use of the library system as a vibrant intellectual and information resource. Direct personal assistance is available from an active reference staff which provides instruction in research methodology, library orientation workshops, computerized bibliographic searches, as well as standard services such as inter-library loan, bibliographies, and the production of several ongoing, current-awareness services.

During the academic year, hours are 8 A.M. to midnight Monday through Saturday, and noon to midnight Sunday.

In Extracurriculars, A Range of Interests

Extracurricular activities provide special opportunities for students to participate in interest groups and programs of their own choosing, all of which provide significant opportunity to develop qualities of leadership.

At Lehigh the philosophy of extracurricular activities is to allow students as much opportunity as possible for setting their own policies, devising their own programs, and assuming full responsibility for their organizations. This philosophy makes it possible for the activities to be extremely significant in the personal development of participants.

The University Forum

Since 1970, Lehigh University has been governed in certain respects and otherwise widely influenced by a unique deliberative body known as the Forum. Its membership includes sixty faculty members, sixty students and five members of the administration, among them the president.

Four Forum representatives—two students and two faculty members—attend meetings of the board of trustees. Assured of access to the information upon which administrative decisions are based and free to inquire into any aspect of Lehigh's operations, the Forum affords faculty and students a voice in university affairs equaled at few institutions.

The Forum has legislative responsibility to set policy on academic program and planning in such areas as freshman seminars, provisional courses, and the academic calendar; social life and regulations, extracurricular activities, and athletics; and areas of academic environment such as pass-fail grading, admission, registration, residence and dining facilities, the libraries, bookstore, and computer services.

The Forum also has the authority to review—with recommendations to the board of trustees or other appropriate bodies—programs in long-range planning, such as academic development, staff requirements, physical facilities, and the over-all budget of the university; community relations programs; administrative appointments at the rank of dean and above; and matters pertaining to curriculum, research, and academic discipline.

The constitution of the Forum has been ratified by the board of trustees, which retains ultimate legal authority over all transactions of the university and its various constituent elements. Members of the board have demonstrated a positive and appreciative attitude toward the Forum from its experimental beginnings to the present.

All meetings of the Forum are open to the university community, with the right to address the Forum provided to any person desiring to do so. The Forum is headquartered in room C-203, University Center.

Honorary and Course Societies

There are more than a dozen honorary and course societies at Lehigh. The three best-known honorary societies are:

Phi Beta Kappa. The oldest national scholastic honorary society (founded December 6, 1776, at William and Mary College). recognizes high academic achievement in the liberal arts and sciences. Admission to its ranks is also held to indicate potentialities of future distinction. The Lehigh chapter was chartered in 1887 as Beta of Pennsylvania.

Beta Gamma Sigma. Election to membership in Beta Gamma Sigma is the highest scholastic honor that a student in business administration can achieve. Beta Gamma Sigma is the only national honorary scholarship society in the field of business administration recognized by the American Assembly of Collegiate Schools of Business.

Tau Beta Pi. Tau Beta Pi recognizes high achievement in all engineering curricula. It is particularly appropriate to recognize this at Lehigh, since Tau Beta Pi was founded on the campus in 1885. The bronze bent in front of Williams Hall commemorates this event.

Other societies are as follows: Alpha Pi Mu, for those in industrial engineering; Beta Alpha Psi, accounting; Chi Epsilon, civil engineering; Delta Sigma Rho-Tau Kappa Alpha, speech; Eta Kappa Nu, electrical engineering; Lambda Mu Sigma, marketing; Omicron Delta Kappa, leadership; Phi Alpha Theta, history; Phi Eta Sigma, freshman scholastic excellence; Pi Tau Sigma, mechanical engineering; Psi Chi, psychology; Sigma Tau Delta, English; and Sigma Xi, research.

Volunteer Services

Varied opportunities for student expression of social responsibility exist through programs sponsored by the Lehigh University Volunteers (LUV). More than 100 Lehigh students participate in volunteer service efforts in the Lehigh Valley area in a range of service programs. LUV is governed by a board composed of coordinators of its various projects.

Most of the volunteer work is done in cooperation with community agencies or schools. Some of the projects include tutorial and teaching aid programs in public and private schools, recreation activities through the YMCA and neighborhood centers, Big Brothers, companionship and group work with children and adults in residential mental health treatment facilities, aid to the elderly in institutions and at home, income tax service at neighborhood centers, blood assurance, and individual and short-term efforts.

LUV is located in room 202, University Center.

Student Organizations

At Lehigh, student organizations embrace a wide range of activities. Course societies promote intellectual interests in various fields of study and develop professional spirit among students. Interest and hobby groups include art, bridge, chess, camera, computer, languages, sailing, skiing, boxing, judo, political clubs, and fencing. These are described in the *Lehigh Handbook* given to every student.

Religious Activities

The religious program is under the general supervision of the university chaplain, who also provides for Protestant chapel services, broadly based and ecumenical in form, varying from the traditional to the informal and innovative. Some services feature the university choir while others utilize folk music. Roman Catholic masses are arranged by the chaplain.

The regular Protestant and Roman Catholic service schedules are announced at the beginning of the year. Jewish

services are available at the nearby Jewish Community Center. Attendance at all religious services is voluntary. The university is nondenominational.

The chaplain's council, consisting of representatives from the various religious groups of all faiths on campus, sponsors a variety of programs together with those organizations and separately under the chaplain's office. The council has sponsored, for example, a luncheon program and a film series, both with discussion; talks by religious leaders and faculty members; and multi-media presentations. Council programs are open to all students.

The Newman Association carries on a program among Catholic students under the guidance of a priest assigned by the Diocese of Allentown to direct the program. The association recently renovated a former private residence on campus for use as a Newman Center. All members of the university community are invited to participate in the association's activities.

The Hillel Foundation program is available to students of the Jewish faith, while various Protestant churches in the community include fellowship organizations for Lehigh students in their programs.

Athletics: Varsity and Intramural

The university's intercollegiate program consists of twenty-two varsity teams in baseball, basketball, cross-country, football, golf, hockey, lacrosse, rifle, soccer, squash, swimming, tennis, indoor and outdoor track and wrestling; junior varsity teams in baseball, basketball, football and wrestling; and junior varsity teams in most of these sports.

Schedules are arranged chiefly with eastern colleges which have athletics policies similar to Lehigh's. Seven varsity sports are available for women. These include basketball, field hockey, lacrosse, softball, swimming, tennis and volleyball.

Normally Lehigh's athletic schedule includes five or six home football games, eight or nine home wrestling meets, nine or ten home basketball games, nine home baseball games and home games in all other sports.

The football team won the National Collegiate Athletic Association Division II championship in 1977. For 1978, the football program joined the newly established Division I-AA. The team did not make the playoffs in 1978.

A comprehensive intramural program includes teams from the residence halls, fraternities and sororities, classes, town, faculty, graduate students, and independent groups. Twenty-four sports activities are included in the program. Students are encouraged to participate in these recreational sports, and awards are given for group and individual excellence.

Of Musical Interest

Lehigh sponsors both a variety of student organizations, which give performances on the campus and away, and a professional concert series, Music at Lehigh, which brings visiting artists to the campus. The choruses, bands, orchestra and ensembles are conducted by members of the faculty and managed by elected student leaders.

Christmas Vespers and Spring Vespers are traditional choral performances. Recent audiences have heard the Mozart *Requiem*, the Schultz *Christmas Story*, the Benjamin Britten *St. Nicolas* and *Ceremony of Carols* and the Stravinsky-Cocteau opera-oratorio *Oedipus Rex*. The choral groups have toured in England, Ireland, Wales and the Caribbean area, and have collaborated with the choirs of Mt. Holyoke, Smith, Wellesley, and the University of Virginia.

The Concert Band regularly plays at the Winter Band and Pops Concert. A recent season included a retrospect of music by Bennington College composer Henry Brant. The Concert Band has performed in Canada, in Washington, D.C., and on the campuses of other colleges and universities.

Performances by the String Orchestra and the Ensembles traditionally close the semester concert season. The ensembles include groups of string, brass, woodwind, percussion and mixed instruments. Recent additions have been ensembles of Renaissance instruments from the university collection.

The Marching Band is widely known for its imaginative, student-conceived precision drills and its spirited performances on the field in support of the Lehigh football team. Ninety-seven men and women are members of this fine unit.

The concert series, Music at Lehigh, presents a variety of concerts and recitals. Some of the artists who have appeared recently are the Goldovsky Opera Company, The Philadelphia Composers Forum, the Cincinnati Early Music Consort, the Mostovoy Soloists and the Nu Liberation Art Unit.

A variety of musical artists are presented by the Student Activities Council. Lehigh students receive further exposure to music through bands hired by individual living groups to perform for weekend parties. "Band parties" are a staple of the Lehigh social menu.

Theatrical Productions

The Lehigh University dramatic society, Mustard and Cheese, operates in conjunction with the division of speech and theater. Theatrical productions vary from the avant-garde to musical comedy.

Membership is open to all Lehigh students and is extracurricular. Opportunities exist for both onstage and backstage participation.

Guest Speakers

The university affords its students the opportunity to hear a wide variety of notable speakers throughout the year. Students are welcome to attend speeches free of charge. In addition to the speakers who are nationally known, the university regularly presents scholars in many disciplines.

Among recent outstanding speakers on the Lehigh campus were U.S. Sen. Richard S. Schweiker (R-Pa.); consumer advocate Ralph Nader; women's rights activist Florynce Kennedy; labor columnist Victor Riesel; scientists Rollo May and Dr. Timothy Leary; Muhammad Ali; Israeli Gen. Moshe Dayan; writer Jimmy Breslin and writer William Rusher. These speakers have appeared under the auspices of the Visiting Lecturers Committee.

The lecture series in international relations and economics has brought both nationally and internationally known lecturers to Lehigh. Among foreign affairs luminaries have been former U.S. secretaries of state Dean Rusk and George W. Ball; Belgium's Paul-Henri Spaak; elder statesman Averell Harriman; General Maxwell D. Taylor; Israel's Abba Eban; Secretary of Energy James Schlesinger; and former British prime minister Harold Wilson.

In economics, the university has hosted John Kenneth Galbraith, the Harvard-based economist, and Marina von Neumann Whitman, the first woman ever to have served as a member of the Council of Economic Advisors.

The Rocco J. Tresolini Lecture in Law, established in 1978, featured as its inaugural lecturer Edward N. Cahn, Lehigh Class of 1955, who is U.S. District Judge for Eastern Pennsylvania. The 1979 lecturer will be Judge A. Leon Higginbotham, Jr., of the U.S. Court of Appeals for the Third

Circuit. This annual lecture series, sponsored by the university's Law and Legal Institutions program, is made possible by a grant from the 1976-77 Annual Fund. Dr. Tresolini, who died in 1967, was a distinguished scholar in the field of American constitutional law and the first chairman of the department of government at Lehigh.

The Andrew W. Mellon Lecture Series, supported by a grant from the Mellon Foundation, brings to the campus speakers with a special interest in the social and human impact of science and technology. Past lecturers have included such notable people as Nobel laureates C. N. Yang and Rene Dubos; historians of technology Jean Gimpel, Melvin Kranzburg, and Carroll Pursell; computer-science pioneer Joseph Weizenbaum, and *New York Times* science editor Walter Sullivan. The series is coordinated by the Humanities Perspectives on Technology program.

Exhibitions

The university presents major exhibitions during the year in the Ralph L. Wilson Gallery in the Alumni Memorial Building and the DuBois Gallery in Maginnes Hall.

These exhibitions are designed to introduce students to well-known American contemporary artists as well as local artists in all expressions of art and related fields, with emphasis on technology and new approaches.

Since 1954, Ralph L. Wilson, Lehigh Class of 1921, has sponsored an annual exhibition of contemporary American paintings. This show focuses on the latest developments on the American art scene, bringing to the campus unknown promising artists, some of whom have later achieved recognition.

The exhibitions in the last few years have included such shows as: Paolo Soleri, Puerto Rican Printmakers, Alice Neel, Louis Stoumen, 19th Century Art, Art and Technology at Lehigh, 3rd U.S. International Graphic Annual, Currier and Ives, and local artists. A number of exhibitions are traveling shows, such as Shades of American Innovative Years (Wilson Collection), Arthur B. Davies (Lehigh Collection), George Harvan Photography Collection, and Louis Stoumen Photography.

An active gallery talk and lecture series brings artists whose works are being exhibited to discuss their work with students.

A new program, also offered as a course, has been established for restoration, curatorial work, and conservation. A conservation laboratory enables undergraduates to understand and practice conservation and preservation of art.

Collections. The university has several major collections. The Grace Collection of Paintings (Reynolds, Romney, Gainsborough, Hobbema, Daubigny, Goya, Inness, etc.) is the most significant.

Others are the Dreyfus Collection of French Paintings (Sisley, Fantin-Latour, Bonnard, Vuillard, Signac, Redon, Courbet, Picasso); the Ralph L. Wilson Collection of American Art Paintings (Prendergast, Sloan, Henri, Luks, Lawson, Bellows, Beal, Glaskens, Hartley, Marin, Burchfield, Zorach, Bouche, Graves, Koch); prints (Whistler, Feininger, Hassam, Taylor-Arms, Pennell, Benton, Kent, Motherwell, Johns, Hayter, Oldenburg, Warhol); The Prasse Collection of Prints (Delacroix, Matisse, Renoir, Blampied, etc.); Isaac Collection of Prints and Paintings (Early American prints of the local area); George and Viola Fearnside Collection (Old Masters drawings and prints); Harry Meyers Collection of Paintings (Sully, Gainsborough); Baker Collection of Chinese Porcelains (Ming, K'ang, Hsi, Ch'ien, Lung, Tang); and The Philip and Muriel Berman Collection of Japanese Prints (Utamaro, Inove, Kotozuka, Onchi).

The Lehigh University permanent collection is viewed as one of the best small private college collections in the East.

Rules & Regulations For Lehigh Students

The university, like the rest of society, has adopted over the years numerous rules and regulations. Lehigh sets forth herewith some of the principal rules and regulations so that currently enrolled and potential undergraduates and graduate students will be apprised of what is expected of them, and what they can expect of the university.

The two principal sections which follow concern academic regulations and those affecting general behavior. Other regulations can be found in the *Lehigh Handbook*, and there is a comprehensive statement of all policy in the publication *Procedures, Regulations and Requirements (PR&R)*. All students are given a *Handbook* at the beginning of the fall semester; *PR&R* is available in the university libraries and in departmental and administrative offices.

Academic Rules

The following information concerning academic and other requirements and regulations should be of interest to all.

Eligibility for Degree

In order to be graduated from Lehigh, a candidate for a baccalaureate degree much achieve a minimum cumulative average of 1.70.

To be eligible for a degree, a student must not only have completed all of the scholastic requirements for the degree, but also must have paid all university fees, and in addition all bills for the rental of rooms in the residence halls or in other university housing facilities. Payment also must have been made for damage to university property or equipment, or for any other indebtedness for scholarship loans or for loans from trust funds administered by the university.

Responsibility for Meeting Requirements

A student is responsible for consulting with the academic adviser or department chairman, prior to the senior year, to ascertain scholastic eligibility for the degree for which this student desires to qualify and to determine that all program and hours requirements will be met.

Final Date for Completion of Requirements

For graduation, all requirements, scholastic and financial, must have been satisfied prior to the graduation exercises.

Notice of Candidacy for Degree

Candidates for graduation on University Day in May or June file with the registrar on or before March 1 a written notice of candidacy for the degree; candidates for graduation in January file a notice of candidacy on or before December 1; candidates for graduation on Founder's Day, the second Sunday in October, file a notice of candidacy on or before September 1.

Failure to file such notice by such dates mentioned debars the candidate from receiving the degree at the ensuing graduation exercises. If a petition for late filing is granted, a fee of $20 is assessed.

Graduating Theses

Undergraduate theses, when required, are accompanied by drawings and diagrams, whenever the subjects need such illustration. The originals are kept by the university, as a part of the student's record, for future reference; but copies may be retained by students and may be published, provided permission has first been obtained from the faculty.

Credit and Grades

A semester hour of college work consists of one hour a week of lectures or classwork, or two or three hours of laboratory work per week (or laboratory work combined with classwork) for one semester. The normal assumption is that the student will be expected to do at least two hours of study in preparation for each hour of classwork.

Latest date for registration. No registration is accepted later than the tenth day of instruction in any semester.

Grading system. Final grades in courses are A, A-, B+, B, B-, C+, C, C-, D+, D, D-, F. The key to grades is as follows: A—excellent; B—good; C—continuation competency, defined to mean that the student has achieved a level of proficiency such that the instructor believes that he or she is prepared to take any subsequent course which has this course as a prerequisite; D—unsatisfactory, but passing, defined to mean that the student has achieved a level of proficiency such that he can apply the course toward graduation, but in the estimate of the teacher he or she has not acquired adequate proficiency to perform satisfactorily in any subsequent course which has this course as a prerequisite; F—failure. Courses taken under the Pass-Fail system are graded P (passing) or F (failure).

A student who withdraws from a course during the first nine weeks of instruction will receive a grade of "W". All students who withdraw from a course after the above date will receive "WF" unless the committee on standing of students, for cause, allows a grade of "W" to be recorded.

A student officially withdrawn from the university after the above dates receives from each instructor a "WP" or "WF".

"Abs." (absent) indicates absence from a final examination.

The grade X is used to indicate absence from the final examination, when all other course requirements have been met. A grade of X, if the absence is for good cause (e.g., illness or other emergency), may be removed by a makeup examination for which a petition must be filed and approved.

The grade N is used to indicate that some course requirements have not been completed. In each case in which this grade is given, the course instructor shall provide written notification to the department chairman stating the name of the student receiving the grade, the reason for the incomplete work, the work to be done for the removal of the N grade, and the grade for the work already completed. The grade N shall be used only where the student establishes to the satisfaction of the instructor that there are extenuating circumstances.

In no case shall the grade N be used to report absence from a final examination when all other course requirements have been met.

A student who incurs an N grade in any course is required to complete the work at the earliest possible date, but not later than the last day of classes in the first full semester in residence (except summer) following receipt of the N grade. A student who incurs an N grade in any course and fails to remove the N grade within the specified period loses all equity in the course.

Failure to take the missed final examination at the first scheduled makeup period will result in the absent grade changing to an F.

The grade XN is used to indicate absence from the final examination and that some other course requirements have not been completed. In each case in which this grade is given, the provisions apply. A student who incurs an "incomplete" in any course and fails to remove the "incomplete" within one semester, loses all equity in the course.

Pass-Fail Systems

Student Option System. This pass-fail grading option is intended to encourage student exploration of challenging courses that would normally be avoided for fear of depressing grade-point averages. It is intended particularly for exploration outside the major field.

Students should also avoid wasting this option on unsuitable courses, such as certain basic introductory courses having no college-level prerequisite or corequisite. The restrictions on the use of the system are listed below. Students who want to take particular courses pass-fail consult (at the time of preregistration) with both their curriculum directors or registration advisers and with the instructors offering the courses under consideration for guidance in this area.

Each curriculum director or registration adviser should consider the intent of this system and the demands of the particular curriculum, then formulate suitable guidelines to aid students in the intelligent use of this option. At the same time, instructors should be prepared to advise particular students as to the suitability of their particular courses for the pass-fail option.

The restrictions on the use of the system are:

1. Before taking a course pass-fail, the student must have achieved sophomore standing, have declared a major, and must be in good academic standing.

2. No more than two courses may be taken pass-fail in any one semester. The student may take a maximum of six courses pass-fail per undergraduate career if engaged in a four-year program, or a maximum of eight courses per undergraduate career if pursuing a five-year, two-degree program.

3. No course may be taken pass-fail that satisfies any part of the graduation requirements for the student's current major except as provided by the designated course system.

4. A student must have the registration adviser's approval to take a course pass-fail. A student must designate the course(s) taken pass-fail by the tenth day of instruction in a regular semester or the fifth day of instruction in any summer session. Prior to this deadline, the student may transfer from pass-fail grading to regular grading or vice-versa without penalty. After this deadline, the student cannot transfer from regular grading to pass-fail grading, or vice-versa.

5. The instructor giving the course is not officially notified which of his students is taking the course pass-fail. Therefore, he reports a regular letter grade for the pass-fail students. The registrar will then record P for reported letter grades of A, B, C, and D; and F for a reported letter grade of F.

6. Under this system, the student surrenders equity to letter grades of A, B, C, or D if the course is passed. A passing grade is applied to the student's graduation requirements but it is not used in the computation of the cumulative average. An F grade shall be computed in the normal manner.

Designated Course System. Also, there are some courses where pass-fail grading may be appropriate for the entire class when evaluation or grading of students may inhibit effective involvement. The restrictions on the use of this system of pass-fail grading are:

1. The course must be explicitly approved for pass-fail grading by the faculty following the procedures of *PR&R* 2.3.07. The committee on educational policy will evaluate requests for exclusive pass-fail grading on the basis of detailed syllabi, explicit statements regarding class hours and preparation hours, and an explanation of how grading will inhibit effective involvement.

2. A student may use only one course where grading is limited to pass-fail to satisfy requirements of the current major and only two such courses to satisfy graduation requirements.

3. A student who takes a course where grading is exclusively pass-fail must include this course within the provisions of restrictions 1 and 2 of the student option for pass-fail grading.

If approved by the faculty, courses may be designated as not available for pass-fail grading.

Grade Values and Probation

The scholastic requirements for each student are expressed in terms of a cumulative scholastic average, which is the weighted point average of all Lehigh grades received.

The cumulative scholastic average will be computed at the end of each semester (and full summer session, i.e., one in which twelve or more semester hours have been rostered). Grades are weighted as follows: A=4, A-=3.7, B+=3.3, B=3, B-=2.7, C+=2.3, C=2.0, C-=1.7, D+=1.3, D=1.0, D-=0.7, F=0.0. WF, Abs., (F), Inc. (F),0.

If a course in which a D+ or lower grade was received is repeated, the grade received upon repetition of the course shall be counted in the cumulative average, and the grade(s) and credit hours received when the course was previously taken will be dropped from the cumulative average.

W, WP, Abs. (X), and Inc. (X) grades are not included in averages. WF is counted as an F. When grades of "absent" or "incomplete" include a letter designation, this letter is used in determining the average.

Probation. A student is placed on scholastic probation when:
a. either the student's cumulative scholastic average or cumulative hours satisfactorily completed fall below these levels:
freshman, first semester, 1.30, 9 hours
freshman, second semester, 1.40, 21 hours
sophomore, third semester, 1.50, 33 hours
sophomore, fourth semester, 1.60, 45 hours
junior, fifth semester, 1.70, 57 hours
junior, sixth semester, 1.70, 69 hours
senior, seventh semester, 1.70, 81 hours
senior, eighth semester, 1.70, 93 hours
b. he or she fails more than seven semester hours in one semester.

Disabilities of scholastic probationers. A student who is on scholastic probation is ineligible for (a) intercollegiate competition and all other activities publicly representative of the university, (b) major office, elective or appointive, in any university organization, and (c) such other activity as may require more time than should be diverted from primary purposes by any student whose academic survival is at risk.

All students, however, have the right to petition to the committee on standing of students for exceptions.

Removal from probation. A student who has been placed on scholastic probation is restored to good standing if at the end of the next semester or full summer session all incompletes incurred during the previous semester have been removed and if the student meets the standards indicated.

Dropped for poor scholarship. A student who makes a 2.20 average or better in a probationary semester but fails to meet the standards is continued on scholastic probation for another semester. A student who makes less than 2.20 average in the probationary semester and fails to meet these standards will be dropped for poor scholarship.

Honors Opportunities

There are three kinds of honors, namely: class honors, graduation honors and departmental honors. Further information is provided in Section III.

Class honors. Upon completion of the work of the freshman and sophomore years, on recommendation of the registrar and by vote of the faculty, class honors are awarded to those individuals who have made an average of 3.0 or better during the preceding academic year.

The names of these students are included in the Founder's Day program in October.

Graduation honors. Degrees *with honors* are awarded by vote of the university faculty to those students who have attained an average of not less than 3.25 in their junior and senior years' work at the university.

Degrees *with high honors* are awarded by vote of the university faculty to those students who have an average of not less than 3.50 in their junior and senior years' work at the university.

Degrees *with highest honors* are awarded by vote of the university faculty to those students who have an average of not less than 3.75 in their junior and senior years' work at the university.

For special cases. Students who spend all or part of their junior or senior years at another institution may qualify for graduation honors under the following conditions:

1. The student must have at least ninety hours or work at Lehigh and an average during the last four semesters in residence at Lehigh which qualified him or her for graduation honors. This average determines the highest category of graduation honors that is possible for the student to attain.

2. The student's average at the other institution when computed with the last four semesters at Lehigh must be such as to still qualify the student for graduation honors. This average may lower the over-all average of the student from one category of graduation honors to another one.

Graduation honors are published in the commencement program.

In all cases, it is required that each student have not less than forty-eight hours of work graded A, B, C, D, or F, including plus (+) or minus (-) designations.

In computing the averages of candidates for graduation honors, semester grades are weighted according to the number of credit hours in the course concerned.

Review-Consultation-Study Period

The Review-Consultation-Study (RCS) period is intended to provide a few days for informal academic work between the end of the formal instruction period and the beginning of the final examinations.

It is expected that students will use this period to consolidate their command of the material in their courses. Faculty members make themselves available to their students at announced times during the period; for example, at the hours when they ordinarily meet classes for instruction.

No quiz may be given during the eight-day period before examinations.

Good Citizenship

Lehigh University exists for the transmission of knowledge, the pursuit of truth, the development of students, and the general well-being of society. Free inquiry and free expression are indispensable to the attainment of these goals. All members of the academic community are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth.

Out of concern for individuality and respect for the privacy of all persons, the university does not impose a common morality on its members. Institutional existence, however, is a privilege granted by public trust, subject to the sanctions and responsibilities defined by the society of which Lehigh University is a part.

Furthermore, society generally provides legal canons, ethical mores, and conduct expectancies pertaining to individual and collective behavior. Thus, the university has the obligation to establish standards of conduct appropriate and applicable to the university community.

Lehigh accepts its responsibility as an institution within the broader social community. The standards of behavior expected of its members are those which the university regards as essential to its educational objectives and to community living.

In accordance with these purposes and objectives, disciplinary action will be taken when necessary to protect the academic integrity of the university and the welfare of its members. An emphasis on counseling and learning will accompany such action.

All members of the university community are subject to municipal, state and federal laws. Obviously the university cannot be a sanctuary for persons who violate these laws. Lehigh is concerned, however, about the rights of students as citizens (with equal protection under the law) and will direct them to legal counsel when necessary.

For just cause (relating to the educational purposes of the university) Lehigh reserves the right to review actions taken by civil authorities against its members. Although ordinarily Lehigh will not impose additional sanctions after criminal disposition of a case, it does have the obligation to introduce counseling and/or disciplinary action if the person's conduct has interfered with the university's exercise of its educational objectives or responsibilities to its members.

Further, the university as a part of the community has an obligation to report serious crimes to civil authorities.

Lehigh relies primarily on general principles and statements of expectation for the guidance of conduct, and assumes that those admitted to the university community are capable of governing themselves accordingly. Specific regulations are kept to a reasonable minimum and are published in the *Lehigh Handbook*. These regulations govern academic honesty and social conduct (including drugs, alcoholic beverages, motor vehicles, etc.). Copies of the *Lehigh Handbook* are made available to every student. Students are responsible for knowing the procedures, rules and regulations as published in the *Handbook*. Freshman residential students should note that permission is *not* granted to them to have motor vehicles on the campus.

Violations of the student conduct code are adjudicated by the committee on discipline which operates under the principles of due process.

Policy on Dissent

Regarding dissent, the university faculty has a policy which emphasizes the responsibility of all members of the university community. The guidelines adopted broadly set forth acceptable forms of dissent on campus.

Generally, the policy on dissent provides the following:

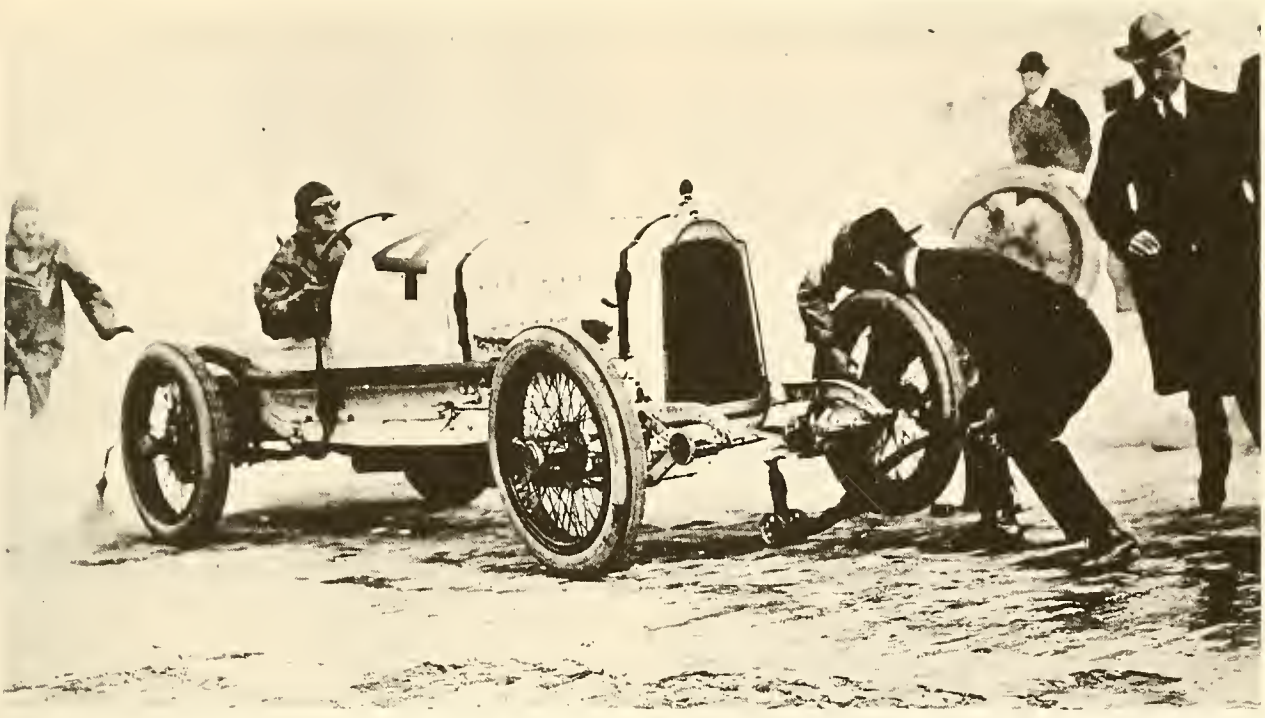
1. Free inquiry and free expression, including the right to open dissent, are indispensable in achieving the goals of an academic community.

2. Coercive activities employed by individuals or groups either to repress legitimate dissent or to demonstrate dissent are a threat to the openness of the academic community and will be dealt with as an extremely serious matter.

3. Where physical coercion is employed or physical obstruction persists and the university is prevented from resolving the matter through its established disciplinary procedures, legal sanctions will be employed.

This statement provides that orderly and peaceful demonstrations on campus are not forbidden unless they interfere with legitimate university function. The authority for making the initial judgment in determining the permissible limits of protest rests with the president and counsel of an advisory committee consisting of four faculty members and four students.

Conduct which exceeds permissible limits will be met with university sanctions ranging in severity from admonition to expulsion, or in cases of aggravated or persistent violation of defined rights, with civil arrest and prosecution under an appropriate charge. Prime authority for discipline rests with the faculty and its committee on discipline.



This Packard Twin-Six racer, the "299," featured an engine that was the prototype for the 70,000 aircraft engines Packard manufactured during World War II. But Packards had always been famous for speed. In 1901, Alden S. McMurtry was arrested in Warren, Ohio, for driving his Packard at 40 miles per hour through the city. It was an international news sensation.

III. What the Three Colleges Offer

Lehigh's undergraduate academic programs fall under the aegis of the university's three colleges, the College of Arts and Science, the College of Business and Economics, and the College of Engineering and Physical Sciences. Boundaries between the colleges are as fluid as possible so that numerous options are open to students. For example, students may take a bachelor of science degree in the College of Business and Economics along with a minor in journalism, a division of the English department in the College of Arts and Science. A variety of interdisciplinary majors and special programs as well as independent studies are designed to enable students to achieve maximum benefit from their Lehigh education.

The College of Arts and Science offers a liberal education in the humanities, mathematics, and natural sciences. Four-year programs lead to a bachelor of arts or a bachelor of science in a major field. A five-year program allows students to combine a bachelor of science degree from the college with a master of business administration. The five-year Arts-Engineering program yields a bachelor of science degree in a branch of engineering and a bachelor of arts degree from the College of Arts and Science.

The College of Business and Economics offers the bachelor of science degree in business and economics which couples a liberal education background with an understanding of the complexities and processes of management. It can serve as the basis for a career in business or for professional studies in fields such as law, business, or related fields. Students can opt to continue their studies for a fifth year and acquire a master of business administration at Lehigh.

The College of Engineering and Physical Sciences offers the bachelor of science degree in eleven programs, combining a strong background in sciences and mathematics with general studies requirements in humanities and social sciences. Students in college programs learn principles they can apply in future professional work; those who plan on further academic training can design a curriculum centering on interests they will pursue in graduate school.

There are numerous opportunities for undergraduates at Lehigh to take advantage of interdisciplinary courses of study described under the section Academic Opportunities of Special Interest. These include such interdisciplinary programs as the pre-law and health professions programs, the College Scholar program, and the Humanities Perspectives on Technology program.

College of Arts And Science

John W. Hunt, *dean*; G. Mark Ellis and Norman P. Melchert, *associate deans*

The College of Arts and Science offers several curricular options: a. a four-year curriculum in the arts and science, leading to the degree of bachelor of arts; b. four-year curricula in the fields of biology, computing and information science, environmental science and resource management, geological sciences, geophysics, and statistics, leading to the degree of bachelor of science in the designated field; and c. a five-year curriculum in arts-engineering leading to a baccalaureate degree from the College of Arts and Science and a bachelor of science degree in the student's field of engineering. d. a five-year program with a bachelor of arts from the College of Arts and Science and the master of business administration degree at the end of the fifth year.

Students in all of these curricula must meet a requirement for freshman English. The normal requirement is English 1 and 2, 4, 6, 8 or 10. See Advanced Placement, page 93.

Specific requirements for many of the degree programs described in this section may be found in Section V.

Bachelor of Arts Degree

The curriculum in arts and science emphasizes a liberal education. It asks the student, in collaboration with the adviser, to select courses to fill three general categories, namely, distribution to insure breadth of education, a major field of concentration to provide depth, and free electives to adjust both breadth and depth to the student's needs.

Distribution Requirements

The objective of the distribution requirements is to give the student an elementary knowledge of the fields of contemporary thought and to orient the student to the world of man and nature. In addition, the preliminary requirements give students experience with each of the college's three distribution areas before a major field of concentration must be chosen.

Distribution requirements are administered by the dean of the college in accordance with the group regulations given below. The student has a wide choice of offerings from which to select courses to fulfill distribution requirements and will have an opportunity to discuss these with the faculty adviser prior to preregistration each semester.

There are two types of distribution requirements: preliminary and upperclass.

Preliminary requirements. These should normally be fulfilled by the end of the student's fourth semester of college work. However, when a student's academic program permits it, they should be completed by the end of the third semester. With the exception of courses in mathematics, natural science, and modern foreign and classical languages, which may be used for either preliminary or upperclass requirements based on the student's progress in the discipline, preliminary courses are indicated by a (P) following the title.

At least one course is chosen from each of two subcategories in each of the three distribution areas listed below:

Area I Humanities
a. Classical and Modern Foreign Languages
b. Literature (courses in English or American literature; Greek, Latin, or modern foreign literature in translation; or foreign literature courses at the third-year level or higher not involving conversation and composition)
c. Philosophy
d. Arts (Architecture, Art, Theater, Music)
e. Religion Studies
f. Interdisciplinary humanities courses

Area II Social Sciences
a. Government, International Relations
b. Social Relations, Psychology courses designated SS (Social Science)
c. History (including Ancient History) and Archaeology
d. Economics
e. Urban Studies
f. Interdisciplinary social science courses

Area III Mathematics and Natural Science
a. Mathematics, Astronomy and Logic
b. Biology
c. Chemistry
d. Geological Sciences
e. Physics
f. Psychology courses designated NS (Natural Science)
g. Interdisciplinary mathematics and natural science courses

Upperclass requirements. To ensure intellectual breadth in the student's progress towards the bachelor of arts degree, a student fulfills upperclass distribution requirements, normally after the major field has been selected.

These requirements consist of twenty hours elected by the student in courses above the elementary level in the two above-listed distribution areas other than the one which includes the student's major. In the case of mathematics, natural science and foreign language courses, all course levels may be used to meet the upperclass requirements. No student may use a single course to fulfill both preliminary and upperclass distribution requirements.

It is expected that each student will fulfill the distribution requirements in a manner that will satisfy the student's intellectual goals and needs as student and adviser perceive them. A student's program, including the choice of distribution requirements, is not official until approved by the adviser.

Language Opportunities

The study of a foreign language is not required for either the bachelor of arts or bachelor of science degree in the College of Arts and Science. However, students in the college are strongly urged to begin or continue the study of foreign languages and cultures by registering for courses offered by the department of modern foreign languages or the department of classics. Students who are qualified are also encouraged to participate in approved study-abroad programs regardless of their major.

The principal purpose of foreign-language study is to develop means of perceiving and understanding a culture other than one's own. The ability to use a foreign language enables the student to communicate with those who are part of a foreign culture. Furthermore, in acquiring such ability, the student sharpens knowledge and use of English.

Students who are planning on graduate study toward the doctor of philosophy degree are reminded that most graduate schools require Ph.D. candidates to demonstrate a reading knowledge of one or two foreign languages. Ability to use foreign languages is beneficial in many careers, such as law, journalism, commerce, industry, and government.

Major Field of Concentration

By the end of the sophomore year, each student in the curriculum of arts and science selects some sequence of studies as a major field of concentration.

A major consists of at least twelve hours of advanced work in the field chosen. Including preliminary college work, the minimum number of hours constituting a major is twenty-four.

The major field of concentration is designed to enable a student to master an area of knowledge so far as that is possible during the undergraduate years. In all fields, certain courses are prescribed, but merely passing courses will not satisfy the major requirements. A student must achieve a minimum 2.0 average in his or her major courses.

Standard major sequences

The student may choose one of the standard major sequences. When a student selects one of these standard majors, the chairman of the department offering the major or the director of a nondepartmental major becomes a student's major adviser and makes out the student's major program. The final responsibility for meeting both major and nonmajor requirements, however, rests with the student.

Special interdisciplinary majors

In addition to the standard major programs, specially structured interdisciplinary major sequences are possible.

For example, a student interested in a professional school of urban or regional planning might wish to structure a special major consisting primarily of courses in government and economics, or in economics and social relations.

Any student may, with the aid of faculty members chosen from the disciplines involved, work out an interdisciplinary major program to include not less than twenty-four hours of related course work, of which at least twelve hours shall consist of advanced courses. The program must be approved by the major advisers and the dean of the college.

Multiple majors

Some students choose to fulfill the requirements of more than one major sequence. A student initiates this by having separate major programs made out by different major advisers.

Because successful completion of only one major program is required for a baccalaureate degree, a student with more than one program is asked to designate one as the administrative major for preregistration purposes but is expected to maintain normal progress in fulfilling the requirements in both.

Bachelor of Science degree

Students desiring to major in the fields of biology, computing and information sciences, environmental science and resource management, geological sciences, geophysics, and statistics may elect to work for a bachelor of science degree. This option is also open to arts-engineers desiring to major in one of these fields.

Normally, a student electing to work for the bachelor of science degree will have a strong preprofessional orientation. He or she will take more courses in the major field of concentration than will a student in the bachelor of arts program. In all other respects the student in a bachelor of science curriculum will meet the same requirements as will the student in the bachelor of arts program, except that the bachelor of science candidate is not asked to fulfill the same distribution requirements.

Arts-Engineering Option

The curriculum in Arts-Engineering is especially designed for students wishing a regular professional education in a field of engineering and also the opportunity to study broadly or in a second field.

Arts-engineers fulfill all requirements for the professional engineering degree for which they are working. However, the first three years of science and engineering courses are scheduled over four years for the arts-engineer. During this period the arts-engineer is a student in the College of Arts and Science pursuing a bachelor of arts and bachelor of science major program.

In normal circumstances the student will complete work for a degree in the College of Arts and Science at the end of four years. The student transfers for the fifth year to the appropriate department of engineering, where he or she pursues a regular fourth year of science and engineering course work in the chosen field of engineering.

These arrangements make it difficult for an arts-engineer to qualify for the bachelor of science degree in the College of Engineering and Physical Sciences before meeting all requirements for the baccalaureate in the College of Arts and Science. In some instances it may be advisable to take the two degrees at the end of the fifth year. To qualify for both degrees a student must submit for the second degree thirty credit hours in addition to the number required for the bachelor of science in engineering alone.

Arts-engineers working for the bachelor of arts automatically fulfill the engineering General Studies requirements while fulfilling the distribution requirements of the College of Arts and Science. Arts-engineers working towards the bachelor of science in biology, computing and information science, environmental science and resource management, geological sciences, geophysics, and psychology must pay special attention to the engineering General Studies requirements, which must be met in time for the student to qualify for the bachelor of science degree in engineering.

Arts-engineers have the same opportunities for multiple majors and special interdisciplinary majors as are available to students working for the baccalaureate in the college.

Pattern rosters which show the normal combination of courses for the first four years of the arts-engineering curriculum are found under Arts-Engineering, page 93.

Graduation Requirements

The bachelor of arts degree (B.A.)

1. The completion with the required average of a minimum of 120 credit hours of collegiate work, apportioned so as to cover the distribution and concentration requirements.
2. A cumulative average of 2.00 or better in the courses required in the student's major program.
3. Completion of all general requirements applying to all candidates for baccalaureate degrees.

The bachelor of science (B.S.) degree in biology, computing and information science, environmental science and resource management, geological sciences, geophysics, and statistics.

1. The completion with the required average of the minimum number of credit hours of collegiate work indicated for the curriculum.
2. Completion of all general requirements applying to all candidates for baccalaureate degrees.

Note: Basic courses in aerospace studies and military science are carried in addition to required courses for either the B.A. or B.S. degree. No more than six hours in either of these subject areas may be counted for credit towards graduation.

Regular Progress

Each student in the college is expected to maintain regular progress towards the baccalaureate degree by carrying a normal course load each semester.

The normal course load may vary between fourteen and seventeen hours depending on the number and difficulty of the courses involved.

Special Opportunities

Five-Year Arts/M.B.A. Program

Students in the College of Arts and Science may enroll in a special five-year Arts/Master of Business Administration program by completing the forty hours of courses listed below in the suggested sequence while completing their major in one of the bachelor of arts programs in the college during their first four years. At the end of this period, if they are admitted to the Graduate School, they may be granted their M.B.A. degree in one additional year, half the time usually required.

The following are the required courses during the four years in the college:

Required Background Courses

* Eco 1	Economics (4)
* Math 41	BMSS Calculus (3) and
* Math 44	BMSS Calculus (3) *or*
* Math 21	Analytical Geometry and Calculus I (4) and
* Math 22	Analytical Geometry and Calculus II (4)

Other Required Courses

** Eco 45	Statistical Method (3) *or*
** Math 231	Probability & Statistics (3)
** Acct 51	Essentials of Accounting (3)
** Eco 105	Microeconomic Analysis (3)
** Acct 111	Computers in Business (3) *or*
** Engr. 1	Introduction to Engineering (3) *or*
** Math 105	Computer Programming (3)
*** Mgt 302	Quantitative Models-Conceptual (3)
*** Mkt 211	Contemporary Marketing (3)
*** Fin 225	Business Finance (3)
*** Law 201	Business Law (3)
*** Mgt 270	Conceptual Foundation of Organizational Theory and Behavior (3)
*** Eco 229	Money and Banking (3)

* recommended in the freshman year
** recommended in the sophomore year
*** junior standing required for this course

Minor Program in the College

Certain departments, divisions and programs in the College of Arts and Science offer an opportunity to minor in an additional field of concentration other than that which the student chooses for the major field of concentration.

Such a minor consists of at least fifteen hours; the specific content is determined by the department, division or program concerned. A minor is optional and, if successfully completed, will be shown on the university transcript in the same manner as the major field of concentration. A 2.0 minimum grade-point average is required for courses in the minor.

If a minor program is not listed under the department desired, the student should consult the department head.

Students will declare a minor through their major advisers, who will keep the appropriate records; it is the student's responsibility to initiate a minor and seek any necessary advice in the department, division, or program offering it.

The minors from College of Arts and Science departments and programs are available for degrees in other colleges within the university at their option.

Education Minor

The purpose of this minor is to help undergraduates explore a career option in school teaching or other professional careers with elenentary, secondary, or special education students. It may accelerate entry into a teaching career because appropriate credits from the minor may be applied toward completion of teacher certification credits for those admitted to Lehigh's graduate Teacher Intern Program. It offers a systematic background of professional education experiences, coordinating practicum activities with theory courses designed to provide a foundation for future educational studies. Its focus is exploratory. No career decision is required but the minor is provided for those with a serious interest in considering the teaching profession.

The experiences of the minor are intended to enrich an individual's understanding of education as a central intellectual phenomenon of our culture and to provide self-understanding of one's own potential as an educator.

An undergraduate may take one or all of these courses during junior and senior years with the approval of his undergraduate faculty adviser. Completion of the minor does not assure admission to the Graduate Intern Teacher Program to become a certified professional. However, if the student passes the screening process on the basis of his previous work and interviews, he/she may enter the Intern Program with advanced standing toward certification.

Program coordinator: Alice Rinehart, Instruction and Curriculum Department, 524 Brodhead Avenue.

15 hours are chosen from among the following courses:

I&C 312	Classroom Practice (1) (must be taken concurrently with I&C 314)
I&C 314	Intern Seminar (2) (must be taken concurrently with I&C 312)
I&C 394A	Special Topics in Instruction and Curriculum: Child Development (3)
I&C 394B	Special Topics in Instruction and Curriculum: Youth in Society (3)
I&C 394C	Special Topics in Instruction and Curriculum: Introduction to Foundations of Education (3)
Elective Education course (appropriate to student's objective (3)	

Special Interdisciplinary Minors

The following special interdisciplinary minors taught principally by the faculty of the College of Arts and Science are available for undergraduates in all three colleges. Further descriptions of courses mentioned in minors listed below appear in Section V.

Interpersonal Behavior in Small Groups & Organizations

This minor has as its general focus the understanding of face-to-face interaction among human beings in small group settings in a variety of organizational contexts. It will be relevant to students interested in personnel, the helping professions, group work, or any occupation requiring interpersonal skills in group settings.

The minor has both a cognitive and experiential learning dimension. Thus the student may become acquainted with the major theories, concepts, and issues concerning interpersonal behavior in social contexts and also with some

of the tools, skills, and insights which promote growth and competence in social interaction. Experiential learning also includes training in techniques of naturalistic observation of social interaction in small groups and organizations.

These courses are not arranged in a sequence; that is, while they individually may put more stress on the cognitive or experiential dimension, none of these courses is prerequisite for any other. Thus students may select any course, subject to the prerequisites and requirements of the university and the department, and availability.

The program coordinator is Robert E. Rosenwein, 1 Price Hall.

15 hours are chosen from among the following courses:

Mgt. 321	Organizational Behavior (laboratory sections only) (3)*
Mgt 316	Organizational Decision Processes (3)*
Psych 121	Encouraging Self and Others (3)
SR 121	Social Psychology of Small Groups (3)
SR 151	Utopias and Alternative Communities (3)
SR 395	Methods of Observation (3)
SR 312	Interpersonal Behavior in Small Groups (3)

*Management 270 is a prerequisite for all management courses.

Jewish Studies

This program enables students of diverse backgrounds to become acquainted with the characteristic features of Jewish culture and religion: the distinctive story of the Jewish people, their trials and achievements, their formative influences on civilization, and their responses to other cultures and peoples. A student may minor in Jewish Studies or take several courses in the field, including independent study.

The program is designed to be of wide interest. A minor can be a broadening addition to various majors. Jewish Studies can serve as a coordinating area study of the interaction between various cultures, religions, and national communities and the Jewish culture, religion, and people. Again, attention to what is characteristic of the Jewish tradition can contribute to an understanding of other traditions. Furthermore, Jewish Studies is relevant to various sociological and psychological questions (including majority-minority relations, prejudice and stereotyping, assimilation and pluralism) and many religious and philosophical issues (such as God, human moral responsibility, and evil and suffering).

Courses must be chosen from several academic disciplines in consultation with one of the program coordinators, Alice L. Eckardt and Harriet L. Parmet.

A minimum of fifteen hours is chosen from these courses. (A maximum of six hours of Hebrew may be counted.):

Clss 241	Pagan, Jew and Christian (3)
English 312	Jewish Literature (3)
Govt/US 328	The American Jewish Community (3)
Hebrew 1	Elementary Modern Hebrew I (3)
Hebrew 2	Elementary Modern Hebrew II (3)
Hebrew 11	Intermediate Modern Hebrew I (3)
Hebrew 12	Intermediate Modern Hebrew II (3)
Hist/RS 154	The Holocaust: History and Meaning (3)
IR 32	Middle East in World Affairs since 1945 (3)
Phil 133	Medieval Philosophy (3)
RS 61	Judaism (3)
RS 111	The Hebrew Bible (3)
RS 151	The Jewish-Christian Encounter (3)
RS/Hist 154	The Holocaust: History and Meaning (3)
RS 163	Contemporary Theology (3)
SR 308	Social Psychology Seminar in Psychology of Judaism (3)

Latin American Studies

The minor in Latin American Studies represents a unique opportunity to explore the language, literature, history, cultures and socioeconomic problems of our neighbors to the South. Moreover, it provides a perspective of the problems of other underdeveloped regions of the world, in contrast to most offerings in the humanities and social sciences which focus on the mainstream of Western culture, notably the United States and Western Europe.

It is worth noting the importance of these cultures in the future of the hemisphere. Latin America is the most rapidly growing part of the world, and by the year 2000 it is predicted that the area will have a population of six hundred million, or twice that of Anglo-America. Several countries, especially Brazil and Mexico, are undergoing rapid industrial expansion. Consequently, besides the personal values to be derived from this curriculum, there are business, government, and related career possibilities.

The minor represents fifteen hours, or five courses, chosen from economics, history, sociology and Spanish in discussion with the coordinator Robert W. Williamson, Price Hall.

I. Required course (3 hours)

Spanish 152	Cultural Evolution of Latin America

II. Elective courses (12 hours) chosen from:

Eco 305	Economic Development of Latin America (3)
History 49-50	History of Latin America (3)
History 265	Mexico and the Caribbean (3)
History 266	Argentina, Brazil and Chile (3)
History 368	Seminar in Latin American History (3)
SR 367	Latin America in Change and Conflict (3)

Courses in Latin American literature (6)

Not more than six hours should be chosen from a given department. A proficiency level in Spanish is required.

Law and Legal Institutions

The minor involves eighteen hours of course work in the College of Arts and Science and the College of Business and Economics. It is available to students in all three colleges. Details are listed on page 50. Interested students should consult Howard R. Whitcomb, department of government.

Russian Studies

The minor in Russian Studies is an interdisciplinary program designed to provide a broad range of study of Russia and the Soviet Union. It can be considered the beginning of a specialization in the area, which can be continued in graduate school, or a useful area of concentration for certain careers after graduation (e.g., foreign service, governmental employment, business, foreign trade, etc.). The program may also be of general interest to nonspecialist students who wish merely to do focused work on the culture and society of the major country in the socialist world.

The minor in Russian Studies requires eighteen hours of formal course work, chosen in consultation with the program director, Donald D. Barry, government department.

I. Required courses (15 hours)

Six hours of college-level Russian based on the student's level of competence; *or*

six hours of Russian literature in translation (6)

Government 61	The Soviet Political System (3)
History 361	A History of Russia to 1855 (3) *or*
History 362	A History of Russia, 1855 to the Present (3)
IR 133	Diplomacy of Russia to 1945 (3) *or*
IR 134	Diplomacy of Russia since 1945 (3)

II. Elective courses (3 hours); one course from the following:
Any other Russian language course (3)
Any other Russian literature course (3)
Government 318 Communist Political Systems (3)
Economics 309 Comparative Economic Systems (3)
Hist 361 or 362 (whichever is not taken under Section I) (3)
IR 133 or 134 (whichever is not taken under Section I) (3)
Special Topics courses in other areas such as psychology or social relations with permission (3)
Field Study in the Soviet Union for academic credit under Special Topics (3)

Humanities Perspectives on Technology

The HPT program reflects a continuing inter-college effort to create, primarily through the development of undergraduate courses, a common ground from which to explore the relations between science, technology and society. Courses are listed on page 158.

Urban Studies

The minor program in Urban Studies is an ideal means of gaining hroad insight into the nature and potentialities of the social sciences, besides being an appropriate vocational choice for students in fields such as civil engineering, management, architecture and social work, among others.

Urban Studies is designed to promote basic understanding of social processes, so that students will learn to perceive in their ever-changing communities opportunities for productive enterprises of their own. For some this will mean careers in public service, but others may contribute much to the betterment of society by successful work in the private sector in the tradition of many Lehigh alumni. The minor in Urban Studies should be of particular interest to students in the College of Engineering and Physical Sciences as well as the College of Business and Economics who wish to maximize the educational value of their elective courses.

The minor consists of eighteen hours of course work selected in consultation with the program director based on the needs and interest of the student with due concern for the over-all intellectual coherence of the program.

I. Required course (3 hours)
Urban Studies 61 The Study of Urbanization (3)

II. Elective courses (15 hours); from the following:
Eco 312 Urban Economics (3)
Eco 37 Transportation and Spatial Economics (3)
Eco 354 Public Finance: State and Local (3)
Arch 151 History of Urban Design (3)
Arch 210 Twentieth-Century Architecture (3)
Gov 77 Urban Politics (3)
Gov 328 Politics of Urban Policy (3)
Gov 331 Internship Seminar (3)
Gov 360 Public Administration (3)
Hist 333 American Urban History to 1880 (3)
Hist 334 American Urban History, 1880 to the Present (3)
Anth 151 Utopias and Alternative Communities (3)
U.S. 62 Contemporary Urban Issues (3)
U.S. 125 American Ethnic Groups (3)
U.S. 363 Philadelphia (3)
U.S. 365 Lehigh Valley (3)
Eco 312 Urban Economics (3)
Eco 337 Transportation & Spatial Economics (3)
Eco 354 Public Finance: State and Local (3)
Arch 151 History of Urban Design (3)
Arch 207 Renaissance Architecture and Urbanism (3)
Arch 210 Twentieth-Century Architecture (3)
Govt 77 Urban Politics (3)
Govt 328 Politics of Urban Policy (3)
Govt 331 Internship Seminar (3)
Govt 360 Public Administration (3)
Hist 333 American Urban History to 1880 (3)
Hist 334 American Urban History, 1880 to the Present (3)
Classics 204 The Ancient City (3)
SR 151 Utopias and Alternative Communities (3)
Anthropology 368 The Urban Community (3)

Certain other courses in relevant disciplines may be included by permission of the director of urban studies, David Curtis Amidon, Jr., minor adviser, 232 Chandler-Ullmann.

Women's Studies

The interdisciplinary Women's Studies Program, located primarily within the College of Arts and Science, seeks to broaden knowledge about issues related to sex roles and society. The program offers a minor, consisting of eighteen hours of course credit, which represents the major research fields of Women's Studies. This minor program is open to anyone in three undergraduate colleges.

In every society the distinction between the sexes is a significant factor in an individual's life. Socialization according to sex affects a person's expectations about appropriate work, social relations, and political position. By focusing attention on those spheres of life in which men have played dominant roles, traditional disciplines have tended to neglect the contribution of women to society and to underestimate the impact of gender differences upon social structure and human lives.

The women's studies minor is an interesting supplement to any undergraduate major. It provides an integrated approach to the role of women in society from the viewpoints of a variety of academic disciplines. The program has three major goals: to promote an understanding of the traditional status and changing roles of women; to stimulate a critical examination of existing sexual roles and stereotypes and the evaulation of alternative arrangements; and to connect issues addressed in the classroom with those raised in the contexts of individual lives and society.

The minor consists of the basic course, Arts and Science 11, Sex Roles and Society, and a choice of five additional courses among those listed below. With the consent of a participating instructor, a student may substitute one Special Topics course. Students arrange their program in consultation with the director of the program, Laura Katz Olson, government department, Maginnes Hall.

I. Required course (3 credit hours)

Arts and Science 11 Sex Roles and Society (3) (team taught by the faculty of the Women's Studies Program)

II. Elective courses (15)

Classics 250 Women in Antiquity (3)
English 77 Poetry of Women (3)
English 311 Literature of Women (3)
French 333 The Great Women Writers of France (in French only) (3)
Government 79 Politics of Women (3)
History 324 Women in American History (3)
Management 472 Men and Women at Work (3)
Philosophy 126 Philosophical Issues in Feminism (3)
Philosophy 221 Sex Discrimination and the Law (3)
Psychology 131 Psychology of Women (3)
Religion Studies 58 Women and Religion (3)
Social Relations 41 Human Sexuality (3)
Spanish 162 Women Writers of Latin America (in Spanish only) (3)

Honors and the College Scholar Program

Qualified students in all curricula of the college may choose to work for either departmental honors or the College Scholar program. Details of departmental honors and the College Scholar program are given on page 49.

Independent Study

Students will find various opportunities for independent study in all curricula and most major sequences. They work out such programs of independent study in collaboration with their major advisers.

On the advise of the chairman of the student's major department, and with the consent of the dean of the college, juniors or seniors of unusual merit who desire to concentrate in their chosen field may be allowed to substitute no more than four or six hours respectively of unscheduled work per semester for an equal number of hours of elective work otherwise required for graduation.

Acceleration

Opportunities for students to accelerate towards graduation include, in addition to advanced placement and work in summer school, rostering course overloads during the regular semester and passing special examinations for credit. Students should see their major adviser or the dean of the college concerning these opportunities.

College of Business And Economics

Richard W. Barsness, *dean*; Max D. Snider, *associate dean*

The College of Business and Economics, which is a member of the American Assembly of Collegiate Schools of Business, offers a program of undergraduate study designed to provide an understanding of the complexities of the managerial process in society, both within and outside the business firm.

Many of the most difficult societal problems today involve decision-making, conflict resolution, and the efficient and effective management of human and physical resources. Studies of business and economics provide fundamental bases for understanding and approaching solutions to aspects of these problems, particularly as they present themselves to business leaders and administrators in other fields.

Thus the college's undergraduate business program stresses analytical and communication skills for the development and articulation of problem-solving techniques. Educational breadth equivalent to many liberal arts programs is accompanied by depth of study of business process such as accounting information systems, financial flows and markets, management processes and the impact of economic variables and forces upon business and social issues.

Breadth. In essence, the undergraduate education deemed most suitable for young men and women who will be the business leaders of tomorrow is formulated as analytically rigorous but with broad educational foundations combined with an exercise in depth of understanding of business process in the economy in which we live.

This education in fundamentals, principles, and problem-solving mental agility provides graduates with various options. Some of the young men and women choosing this curriculum have already settled upon business careers. Others will use it as a base for further professional studies, in law, graduate business schools, or specialized graduate training in economics, operations research, or other related fields. Still others go into administrative careers in government or nonprofit institutions such as hospitals and universities. Others apply their talents to professional accounting, financial investment, or management consulting careers. Others teach economics or administrative science.

Undergraduate education must first of all provide the solid base of analytical skills and acquaintance with a segment of significant and relevant phenomena of our society. Equipped then with learning skills and intellectual facility in problem solving, the student's ultimate career must be of his or her own making.

Business today can no longer be approached with narrow or superficial vocational training. Its problems are strongly conditioned by the state of the economy and even by social issues confronting modern business executives. Thus a strong basis in the social sciences is essential to understanding the nature of business organizations. The student must also touch base with physical sciences and technology. Finally, mathematics and computer systems are essential elements of modern decision-making processes. An introduction to all of these is provided in Lehigh's undergraduate program in business and economics.

There are three departments through which much of the student's work is carried out: accounting and law; economics; and management, finance and marketing.

Options. At the same time the student of today must be provided with options. Initiative and motivation would be stultified in a straight-jacketed curriculum. To avoid such rigidity, the necessary exposures to science, language, and other arts are accomplished by optional requirements, within each of which the student has wide choice. Thus the basic curriculum rationale is similar to a distribution requirement in liberal arts, to guarantee breadth of undergraduate educational experience.

Additionally, however, approximately twenty credits required for graduation are completely open for selection on a free-elective basis. Thus some students take double majors, since intensive specialization is not required, others carry majors into more advanced levels, while still others choose work across the university ranging from humanities to technical engineering subjects, achieving even greater breadth or more specially tailored combinations than are provided in standard requirements.

The degree of bachelor of science in business and economics may lead directly to a fifth-year achievement of the master of business administration degree in the college or at another institution.

In addition to the MBA, the college also offers the following post-baccalaureate degrees: the doctor of philosophy, the master of arts, the master of science, the doctor of arts, and the master of science in management science. These are described in Section IV.

Goals of the College

Objectives of the College of Business and Economics are to provide an understanding (at the undergraduate level) and

managerial and or research-teaching expertise (at graduate levels) of the nature of business enterprise decision-making and resource management in the economy. Undergraduate objectives may be summarized as follows:

1. To provide tools of analytical rigor and perspective for continuing learning abilities with respect to the nature of business and its role in the economy.

2. To increase communication skills.

3. To provide breadth of appreciation of the scientific, technological, social and human features of the world in which business is carried on.

4. Through a common body of knowledge to stimulate interest in and acquaint a student with basic business and economic systems of pricing, financial accounting, distribution and management processes.

5. Through a major, to provide each student with a learning exercise in depth in at least one area of business or the economy in which business operates, such as accounting systems, finance, economics, economic statistics, foreign careers, management or marketing.

6. To work increasingly with mature students for intermediate and upperclass subject areas of business and economics, as an introduction to professional work or a sound basis for acquiring experience in the field or for graduate education.

Bachelor of Science in Business

To obtain the bachelor of science degree in business and economics, 120 credit hours are required.

College Core Requirements (55 credits)

English and Mathematics (12 credits)

Engl 1	Composition and Literature (3)
Engl 2, 4, 6, 8 or 10	Composition and Literature (3)
Math 41	BMSS Calculus I (3)
Math 44	BMSS Calculus (3)

Note: BMSS stands for biological, management and social science.

Business and Economics Core (43 credits)

Eco 1	Economics (4)
Eco 45	Statistical Methods (3)
Eco 229	Money and Banking (3)
Eco 105	Microeconomic Analysis (3)
Eco 119	Macroeconomic Analysis (3)
Acctg 51	Essentials of Accounting (3)
Acctg 52	Essentials of Accounting (3)
Acctg 111	Computers in Business (3)
Law 201	Business Law (3)
Mkt 211	Contemporary Marketing (3)
Fin 225	Business Finance (3)
Mgt 269	Management of Operations in Organizations (3)
Mgt 270	Conceptual Foundations of Organizational Theory and Behavior (3)
Mgt 301	Business Management Policies (3) *or*
Mgt 306	Entrepreneurship and Business Policy (3) *or*
Eco 333	Managerial Economics (3)

Major Program (15 credits)

Before the end of the first semster of the junior year, students select a major or field of concentration. A major program consists of sequential or related courses in accordance with one of the designated major programs, as detailed in Section V. Five majors are offered: accounting, economics, finance and law, management, and marketing.

Optional Courses (30 credits)

The student elects three hours of courses from each of the following four groups:
1. English, speech, journalism or modern foreign languages.
2. Government, history, international relations, psychology, and social relations departments (including the division of urban studies).
3. Fine arts, classics, mathematics, music, religion studies, and philosophy departments.
4. Biology, chemistry, geological sciences, and physics departments.

The remaining eighteen hours must be taken in any one or more of the departments listed in the four groups above or any one or more departments in the College of Arts and Science, as follows: biology, classics, English, fine arts, geological sciences, government, history, international relations, mathematics, modern foreign languages and literature, music, philosophy, psychology, religion studies, and social relations. One-hour courses are not accepted for the optional courses but may be counted toward electives.

Electives (20 credits)

Normally, any courses in the university for which a student has the prerequisites may be used as electives as long as such courses carry university credits.

Advanced military science and aerospace studies courses may be counted as electives up to six credits, but freshman- and sophomore-level courses in military science and aerospace studies do not carry credit against the 120 hours required for graduation.

Planning Courses of Study

In addition to freshman English and mathematics requirements, each freshman enrolled in the College of Business and Economics registers for Economics 1.

For the fourth and possibly fifth courses, the student takes courses toward the optional requirement each semester of the freshman year. The normal program for freshmen is fifteen hours each semester.

Accounting 51 is taken in the first semester of the sophomore year. Other business and economics core requirements should be selected with some sampling of introductory courses that may help the student choose the major in the junior year.

The pass-fail option is available for students in the college for elective credits. Courses with passing letter grades must be submitted to meet the core, major program, and optional requirements. Courses taken on a pass-fail basis are classified as elective courses.

The senior year's work must be taken at Lehigh University.

College of Engineering and Physical Sciences

John J. Karakash, *dean*; Curtis W. Clump and Arthur F. Gould, *associate deans*

The College of Engineering and Physical Sciences includes eight departments. It offers undergraduate and graduate degree programs at the bachelor, master and doctor of philosophy levels.

The undergraduate degree programs or curricula, each leading to the bachelor of science degree are as follows:

chemical engineering
chemistry or biochemistry
civil engineering
electrical engineering or computer engineering
fundamental science
industrial engineering
mechanical engineering and mechanics
metallurgy and materials engineering
physics

Information about each of these programs may be found under alphabetical listings in Section V.

Each of the curricula includes course requirements in the physical sciences, mathematics, engineering sciences, and the advanced engineering or science course work essential for the particular degree. In addition, each curriculum has General Studies requirements in the humanities and social sciences.

In the past engineering education was identified explicitly and uniquely in terms of the needs of industry. Present-day engineering programs continue to provide and emphasize such preparation. However, the flexibility inherent in the curricula enables students to design personalized programs leading directly into other professional colleges or professions such as medicine, law, government, management or architecture.

The college encourages such mobility. Experience shows that the background provided through the college programs, including "the engineering approach" to identification, articulation and resolution of problems, finds increasingly wider applicability in those areas of activity which call for a combination of practical and conceptual intelligence.

The physical sciences curricula of the college stresses fundamentals while providing opportunities for electives in each of the substantive fields within the sciences. Senior-year programs in the sciences can be planned to facilitate transition to either graduate school or industrial laboratories.

Undergraduates with interests in such topical areas as environmental control, biomedical instrumentation or aerospace can pursue their interests through electives provided in each of the curricula. Effective preparation for graduate study in such specialties consists of basic programs in engineering and science, along with electives especially chosen for the field of interest. Such electives are chosen from among all the offerings of the university and are usually taken during the senior year.

Change of curriculum. The early indication of curriculum choice by students in their application to the university is not a commitment on their part. In the second semester of the freshman year, just prior to preregistration for the sophomore year, students indicate their choice of curriculum.

However, since the sophomore-year programs for several curricula are very much alike, it is possible to transfer from one curriculum to another as late as the end of the sophomore year. This is done by means of a petition following consultation with curriculum advisers. There are instances where such a transfer may require one or two courses to be taken during a summer session at Lehigh or elsewhere.

The college recognizes that the four-year programs are not intended to train specialists in a given area but rather to educate students in terms of principles they will apply to problems they encounter in their future professional work. It is for this reason that the degree awarded upon graduation is bachelor of science in a particular division of engineering or science.

Five-year programs combining the liberal arts and engineering or electrical engineering and physics are also provided. In each of these combined curricula, one bachelor degree is awarded upon the successful completion of four years of study, and a second bachelor degree is awarded at the end of the fifth year.

The college curricula are designed to provide students with as much latitude as can be made available without compromising the balance and integrity expected of them by accrediting agencies. This is satisfied with the "minimum" program of each curriculum. On the other hand, the college expects each of its students to take full advantage of all opportunities open to them and complete "normal" programs. In each of the college curricula, a few junior- or senior-year electives are indicated as follows: elective (0-3), or electives (3-6), (6-9), etc. Normal programs are those including the higher of the two credit hours shown for each such elective, and minimum programs are those including the lower of the two numbers.

Personal Interest. The college, through its advisers, is prepared to help students to use the six to twelve hours of "personal electives" which make the difference between the minimum and normal programs, along with other electives as available in the curricula, toward a personal-interest development program. This may take the form of some concentration in an option or specialty within a student's own degree program, or alternately in a topical area outside a student's own department or outside the college.

Qualified college juniors planning to continue their formal education into graduate school are urged to take advantage of the flexibility in their programs and design their senior-year program in a manner which provides an effective foundation for a master's degree program at Lehigh. Qualified students who plan their programs in this manner can, upon recommendation of the department and with the approval of the dean of the Graduate School, receive credit towards their degree for graduate-level courses they complete above their minimum undergraduate program.

Recommended Freshman Year

The following outline of work for the freshman year is most easily scheduled and satisfies the requirements for all students in the college. For schedules of the work required in the following three years, please refer to the course descriptions for the specific curriculum, Section V.

freshman year, first semester (15-16 credits)

Engl 1	Composition and Literature (3)
Chem 21, 22	Introductory Chemistry Principles and Laboratory (5) *or*
Phys 11, 12	Introductory Physics I and Laboratory (5)
Math 21	Analytic Geometry and Calculus (4)
Engr 1*	Introduction to Engineering Problems (3) *or*
General Studies, Humanities or Social Science (GS) elective (3-4)	

freshman year, second semester (15-16 credits)

Engl 2**	Composition and Literature (3)
Phys 11, 12	Introductory Physics I and Laboratory (5) *or*
Chem 21, 22	Introductory Chemistry Principles and Laboratory (5)
Math 22	Analytical Geometry and Calculus II (4)
Engr 1	Introduction to Engineering Problems (3) *or*

General Studies, Humanities, or Social Science (GS) elective (3 or 4)

*Engineering 1, Introduction to Engineering Problems, is a three-hour course offering programming of elementary engineering problems in compiler language through lecture and preparation of problem solution in fields represented by the college curricula. Students elect a three-credit humanities or social science course (GS) from the GS listing.
**Engl 4, 6, 8, or 10 may replace Engl 2.

General Studies

The General Studies (GS) program which involves a minimum of twenty-five credit hours normally spread over four years, is designed to enable students to range widely or to delve deeply into the humanities or the social sciences with the purpose of exploring the value systems, assumptions, and methodologies contained in these areas.

Since all students in the college are expected to complete specified sequences of courses in the physical sciences, and other electives are available for related courses in natural sciences, the General Studies program is restricted to the humanities and social sciences.

In addition, students pursuing a bachelor of science degree program in the college can, if they so choose, organize their general studies program to achieve a minor in any one of the established areas in the humanities or social sciences.

This requires:

1. Identifying the area of interest, i.e., sociology, philosophy, art and architecture, literature, etc., and obtaining the approval of the chairman of General Studies. A conference with the chairman of General Studies is the first step toward this goal.
2. Formulating a course program in the area of concentration jointly with a member of the faculty representing the area of concentration. The names of faculty representatives will be given to students by the chairman of General Studies.

In general, the "minor" is earned upon successful completion of a program of not less than fifteen credit hours in the area of concentration. In certain cases, a senior paper also may be required. In each and every case the faculty adviser in the area of concentration must recommend the student's work for such recognition. It is essential that students planning to earn a minor in General Studies initiate action soon after their freshman year but not later than the beginning of the fifth term.

The General Studies sequence of the college starts in the freshman year with six hours of English composition and literature, and a three-hour social science or humanities elective. In the sophomore year, four hours of economics are required. By the end of the senior year, a minimum of twelve additional hours (four courses) is completed to satisfy the requirement of a total of twenty-five hours in General Studies. Several courses such as History 1 and 2, Course of Civilizations, and Philosophy 100, Philosophy of Contemporary Civilizations, have been developed to meet General Studies objectives.

Courses qualifying for credit in General Studies are as follows:

Required Courses (10 credit hours)

Engl 1, and one course from among Engl 2, 4, 6, 8 or 10; Eco 1

Electives in humanities and social science (15 credits)

Classics, any course

Economics

Eco 105	Microeconomic Analysis (3)
Eco 119	Macroeconomic Analysis (3)
Eco 229	Money and Banking (3)
Eco 303	Economic Development (3)
Eco 305	The Economic Development of Latin America (3)
Eco 309	Comparative Economic Systems
Eco 310	Economic Evolution (3)
Eco 311	Economics of Resource Use (3)
Eco 312	Urban Economics (3)
Eco 313	History of Economic Thought (3)
Eco 317	Development of American Business (3)
Eco 335	Labor Economics (3)
Eco 337	Transportation and Spatial Economics (3)
Eco 338	Labor Market Institutions (3)

English, any course

Art and Architecture, any except Arch 143, 144, 145, 152

Foreign Language, any advanced course. If elementary language study is elected, a minimum of one year must be in one language in order to receive General Studies credit.

A student may not elect an elementary course in any language in which he or she has entering credit.

Freshman Seminar

Government and Urban Studies, any course

History, any course

Humanities Perspectives on Technology

Information Science

IS 202	Computer and Society (3)
IS 301	Descriptive Linguistics (3)
IS 302 (Psych 329)	Psycholinguistics (3)
IS 320 (Psych 308)	Information Processing: Human and Machine (3)
IS 324	Development and Decline of Human Information Processing Abilities (3)

International Relations, any course

Journalism

Journ 21	Creative Writing (3)
Journ 22	Creative Writing (3)
Journ 111	Problems in Advanced Reportage (3)
Journ 114	Reporting on Public Affairs (3)
Journ 115	Interpretive Writing (3) spring
Journ 118	History of American Journalism (3)
Journ 120	Journalism Proseminar (3) fall
Journ 121	Law of the Press (3)
Journ 122	Law of the Press II (3)
Journ 123	Basic Science Writing (3)
Journ 124	Politics of Science (3)
Journ 125	Environment, the Public and the Mass Media (3)
Journ 126	Writing About the Environment (3)
Journ 131-136	Science Writing Practicum (1-3)
Journ 311	Science Writing (3)
Journ 312	Advanced Science Writing (3)
Journ 313	Special Topics in Science Writing (3)

Law 11	Introduction to Law (3)

Music, any course other than 21-78

Philosophy, any course except Phil 14

Psychology

Psych 1	Introduction to Psychology (3)

Psych 75 (Phil 75) Behavior Control and Human Values (3)
Psych 81 Insanity: Psychological and Legal Views (3)
Psych 107 Child Psychology (3)
Psych 108 Adolescent and Adult Psychology (3)
Psych 131 Psychology of Women (3)
Psych 205 Abnormal Psychology (3)
Psych 241 Psychological Principles in Systems Design (3)
Psych 308 (IS 329) Information Processing: Human and Machine (3)
Psych 311 History of Modern Psychology (3)
Psych 320 (IS 302) Psycholinguistics (3)
Psych 331 Humanistic Psychology (3)
Psych 353 Personality Theory (3)
Psych 342 Construction of Psychological Reality (3)

Religion Studies, any course

Social Relations, any course except SR 171

Speech and Theater, no speech course; any theater course except 11, 12, 13, 61, 62

Technical Minors

Minors are available to students in the College of Engineering and Physical Sciences.

First, a student desiring a concentration of courses in an area of the humanities and social sciences may develop a minor in the General Studies program.

Second, minors are also offered in technical or scientific specialties that are not normally included within the normal curricula. Each program contains at least fifteen credit hours of technical and/or scientific courses. Often some of these courses can be chosen as approved electives in the student's major curriculum; others are chosen as free electives.

Presently, technical and scientific minors are available in chemical processing (not open to chemical engineers), computer engineering (not open to electrical engineers), molecular biophysics (not open to engineering physicists or fundamental science majors concentrating in this area), production management (not open to industrial engineers), fluid mechanics, and solid mechanics. Additional minors will be offered as interest warrants.

In some special cases a student in the college, able to incorporate electives within the curriculum which happen to satisfy the requirements of a minor offered in the College of Arts and Science, can, with the permission of the adviser in that college, earn the minor. It must be understood that the courses involved must be completely compatible with the curriculum of the major.

Graduation Requirements

Students in good academic standing earn their degree by meeting the requirements of their specific bachelor of science curriculum and university requirements. Waiver of program requirements is approved through petition endorsed by the department and the committee on standing of students.

Students are expected to satisfy the credit-hour requirements of their chosen curriculum. Basic military science or aerospace studies credit hours are in addition to the credit hours specified by the curriculum. Advanced military science or aerospace studies can be included within the normal program of each curriculum, but not within the minimum program.

Students are urged to confer with their curriculum adviser on all matters related to their program.

Honors Programs

Each department offers honors work, and adapts this to its curriculum.

Outstanding students may receive permission to do independent study on an unscheduled basis, thereby proceeding more rapidly and more deeply than is possible in regular programs. This enables students who are qualified for and interested in this work to proceed in a direction agreed upon with their honors adviser, leading to the preparation of an undergraduate thesis.

For further information, students should see their adviser.

Inspection Trips

Inspection trips to industrial plants are a required part of specific courses in various engineering curricula. Written reports may be required. These trips are generally held during the senior year and involve an average expense of $25 to $50. The location of the university in the center of industrial activities of various types furnishes unusual opportunities for visits of inspection to engineering plants.

Arts-Engineering Curricula

Under the five-year plan, the student is in the College of Arts and Science for four years, earning the bachelor of arts or bachelor of science degree on completion of a program which includes, along with specific bachelor of arts training, the fundamental mathematical, scientific, and engineering subjects of the chosen engineering curriculum.

In the fifth year, the student is enrolled in the College of Engineering and Physical Sciences, carrying on a program leading to the bachelor of science degree in the selected curriculum.

Engineering students who decide at any stage of their program to work for both the bachelor of arts and bachelor of science degrees are urged to work with their advisers toward the formulation of an augmented program meeting the requirements of both degrees. If the decision is made prior to the third year, both degree requirements may be satisfied within a total of five years.

The General College Division: No Degrees

The General College Division supplements the work of the established undergraduate curricula by meeting the educational needs of certain special groups of students.

The division aims to provide an opportunity for individuals who are not planning a four-year program to pursue general or specialized work. It can provide a trial period for those who wish to become candidates for baccalaureate degrees but whose preparatory training does not fully satisfy the entrance requirements for the curricula of their choice. Adults can continue their education in the General College Division without being committed to a restricted or specialized program.

Although all work available through the General College Division will be found at present among the regular offerings of the several departments, the work taken by students in this

division is not regarded as primarily preparation for admission to the upper classes of the university; rather, the courses are looked upon as complete in themselves.

Each student in the General College Division has an individual program, one not subject to distribution or curriculum requirements, yet one limited by the student's ability to meet the prerequisites of the course which he or she desires to take. With but few exceptions, the student enrolled in this division enjoys the same privileges as all other undergraduates in the university, including eligibility to unrestricted prizes, access to student aid, and the right of petition; and is also subject to the same general regulations, those pertaining to scholastic probation not excepted.

The General College Division student will not, however, be a candidate for a degree, except in those instances where transfer to one of the undergraduate programs of study leading to degrees is approved by the committee on standing of students.

Unusual Academic Opportunities

Lehigh has traditionally taken advantage of its relatively small size and lack of rigid departmental lines to develop flexible and interdisciplinary programs.

On the graduate level, a student may choose to pursue work by field rather than department in such areas as computer science, applied mathematics, management science and molecular biology. Graduate students may do thesis or dissertation research in one of eight interdisciplinary centers, which are described in the section starting on page 68.

Interdisciplinary work on the undergraduate level can be arranged in each of the colleges for the student desiring a concentration in a field outside a usual major.

The program in urban studies, outlined in Section V, Course Descriptions, is intended to provide background for undergraduates who wish to enter professional careers that require interdisciplinary knowledge of the problems of urban life or who will be pursuing graduate studies in urban affairs. Several cooperating departments associated with the Center for Marine and Environmental Studies provide instruction in marine ecology, biological oceanography, sanitary microbiology, water supply and transport, and environmental planning.

Because environmental studies are interdisciplinary in nature, the emphasis in these courses is to provide a general introduction to the undergraduate planning graduate study in a specialized area.

Accelerated Programs

It is possible for Lehigh students to accelerate their programs so that they may graduate in as little as three years. Such programs are made possible by credits awarded for advanced standing upon admission, credit by examination, overloads, and summer work. Again, interested students should consult with their curriculum advisers.

Afro-American Studies

The university offers a number of courses that are relevant to Afro-American studies. Representative courses are Engl 319, The Black in American Literature; Govt 352, Civil Rights; Hist 331, The Negro in America; SR 368, Urban Community. Students who are interested in Afro-American studies work out an interdisciplinary major with their advisers or with the dean of their college.

Apprentice Teaching

The apprentice teaching program is designed to benefit students with junior or senior standing who wish to learn about teaching under the guidance and supervision of an experienced teacher. The apprentice receives instruction and experience in many aspects of the teaching process while working with the master teacher in a course taught by the master teacher. Master and apprentice teachers are responsible for submitting to the department chairperson an outline of the activities in which the apprentice will participate. The outline must be approved by the chairperson and kept on file.

Apprentices typically receive three hours of credit for regularly attending classes, doing a limited amount of observed lecturing or leading of discussions, assisting in making up and evaluating some written assignments, and being available for individual consultation with students.

Apprentice teachers should have an over-all cumulative grade point average (GPA) of 2.8 or better or a cumulative GPA of 3.32 in the major field in which the apprentice teaching is done, and should previously have taken for credit the course in which they will apprentice or its equivalent. A student may register for apprentice teaching only once each semester, and only twice during the college career, for a total of not more than six hours of credit. The student may register to be an apprentice teacher in a given course only course.

A graduate student who is not a paid teaching assistant may register for apprentice teaching, but the department decides whether the student may receive credit which will count toward fulfilling degree requirements. The apprentice is graded for work in the course by the master teacher.

Students who wish to do apprentice teaching in extradepartmental courses, such as those offered as Freshman Seminars, may do so with the approval of the director of the program. In provisional courses or courses cross-listed in several departments, the approval of the chairman of the department in which the course is taught is required. In such cases, the student registers for the 300 courses with the same heading as the course in which he or she is an apprentice (e.g., FS 300-Apprentice Teaching in FS 97C).

This program carries the following provisions: Except with the dean's approval, professors do not accept more than two apprentice teachers per semester; master teachers supervise all aspects of the apprentice's work; the duties of the apprentice teacher are restricted to those which will provide a learning experience for the apprentice without inhibiting the educational experience of students taking the course; the duties of apprentice teachers are not to be confused with those performed by paid graduate teaching assistants; the master teacher provides a report on the apprentice teaching experience to the department chairperson and to the dean of the college.

Cooperative College Program

Lehigh University is a member of the Lehigh Valley Association of Independent Colleges (LVAIC). This consortium also includes Cedar Crest and Muhlenberg colleges in Allentown, Moravian College in Bethlehem, Allentown College of St. Francis de Sales in Center Valley, and Lafayette College in Easton.

Under an agreement among the colleges of LVAIC, student on one campus may cross-register for courses given on another campus. Students desiring to take advantage of this opportunity must obtain the consent of the course instructors and advisers concerned and accept differences in calendar and course scheduling. They provide their own transportation.

A student taking a course on another campus under this arrangement does not pay extra tuition for the privilege, and the course and the grade assigned in it are recorded on the transcript of the home institution. The agreement applies only to undergraduate students and extends to both the academic year and summer sessions.

Five-Year, Two-Degree Programs

Lehigh's five-year, two-degree programs enable a student to receive either two bachelor degrees or a bachelor and a master's degree upon completion of five years of study.

Most five-year, two-degree programs appear in the description of courses under Arts-Engineering (page 93) and Five-Year Programs (page 142). It is possible to arrange for a dual bachelor degree program even after studying at Lehigh for some time. Engineering students, for example, who decide at any stage of study that they wish to meet the requirements for both the bachelor of arts and bachelor of science degree may complete the combined requirements in five or possibly six years, depending on when they decide to try for both degrees.

Of increasing interest to undergraduates are the two-degree, five-year programs which enable one to secure a bachelor and a master's degree. Because Lehigh's well-established graduate programs are closely integrated with the undergraduate programs, it is possible to consider programs leading to the engineering-master of business administration degree, the arts-master of business administration degree, the engineering-master of science in materials program, or the fifth-year program in the graduate-level School of Education which enables those receiving a bachelor of arts degree to accomplish professional teacher training and serve as salaried interns in public schools. After the completion of one year of full-time teaching, students can receive the master of arts for secondary teachers or the master of education degree for elementary teachers.

Many other five-year, graduate-level combination programs exist, and students are advised to consult with their adviser in planning such programs.

Freshman Seminars

Interdisciplinary problem-centered Freshman Seminars (FS) are offered each semester to freshmen enrolled in any curriculum.

A three-credit-hour seminar serves as a general studies option in the engineering and physical sciences curriculum, a preliminary distribution elective in the arts and science curriculum, or an arts option or free elective in the business and economics curriculum.

Freshman Seminars have been selected from those proposed by professors who have specified a transdisciplinary inquiry which they would like to pursue in seminar fashion with a group limited to fifteen freshmen. Such study gives each student experience in relating contemporary cultural problems to the many disciplines in the humanities and sciences. It also provides an opportunity to make initial exploration of one or more of those disciplines, thereby helping to season the student's judgment as to how his or her university education could best be structured.

Freshman interested in enrolling in a Freshman Seminar are invited to use the application form that is part of the Freshman Seminar Announcement each semester, which accompanies preregistration materials. After consultation with the faculty adviser, students submit these applications with other preregistration materials. The class roster for each Freshman Seminar is made up of students from each of the colleges. Beyond that basic restriction, selection of students is made by random choice from among the applicants. Those who apply but are not chosen in the fall semester are given priority in the event they apply again in the spring semester.

Typical Freshman Seminars offered in recent semesters include: "Intuition and Rationality"; "World Economic Issues"; "Myths We Live By"; "Technology and World Order"; "Systems Thinking"; "Visual and Verbal Languages"; and "Images of Self and Reality".

The Harrisburg Urban Semester

Undergraduates from all parts of the university can spend either the fall term or the spring term in Pennsylvania's capital city of Harrisburg to study urban problems. They live and work with students from other participating Pennsylvania colleges and are supervised by The Harrisburg Urban Semester (THUS) faculty or member college faculty.

The curriculum consists of three basic parts: internship, a specialized mini-seminar and an urban seminar which brings together current interns. Internships, which are the core of the program, are available in federal, state, county, city, private and religious organizations. They range from environmental protection, prison and probation, drug rehabilitation, day care, state legislature, mental health, city planning, public works, legal services, and community organization.

Students in all fields of study are encouraged to participate. Upon completion of the semester, students receive sixteen semester hours of credit.

Health Professions Programs

Schools of medicine, dentistry and veterinary medicine stress the importance of a broad general education as well as prescribed studies in the sciences. As long as candidates have the essential courses in biology, chemistry, physics, and mathematics, they may major in any of the three undergraduate colleges.

A health professions advisory committee, which includes faculty members from biology, chemistry, engineering and physics, provides information during freshman orientation to interested students and actively works with health-professions candidates from the sophomore year on to assist them in planning for entrance into professional schools in conjunction with their major advisers.

Lehigh affords two special baccalaureate doctor of medicine degree programs for students interested in becoming physicians. These limited-enrollment programs are offered in association with two Philadelphia-based medical schools.

A bachelor of arts program in premedical science or a

bachelor of science program in chemistry are available in connection with Hahnemann Medical College. A bachelor of arts in premedical science program is associated with the Medical College of Pennsylvania. Descriptions of these accelerated courses of study may be found below.

Students interested in optometry, pharmacy, podiatry and other allied health fields may obtain information from the health professions advisory committee in planning their courses with their academic advisers.

Among the health professions programs offered at Lehigh are two introduced during 1975 which provide for accelerated education leading to both the baccalaureate and doctor of medicine degrees within a total of six or seven years of study. A limited number of exceptionally well-qualified students are accepted for these special programs.

Lehigh-Hahnemann M.D. Program

Lehigh University, in cooperation with Hahnemann Medical College and Hospital in Philadelphia, offers an accelerated seven-year program leading to a combined baccalaureate degree and a doctor of medicine degree. The program is designed to increase the number of primary health care physicians in the Lehigh Valley and in rural eastern Pennsylvania by giving preference to well-qualified students from these areas with a strong inclination toward family-practice medicine.

Two curricula are offered to Lehigh students who desire to be considered as candidates for the Hahnemann program: a premedical science and a chemistry major. In both programs the student spends three academic years and one summer at Lehigh completing courses. The curricula followed meet the biology, chemistry, physics and mathematics prerequisites required for medical admission and allows some flexibility in the selection of elective courses.

A joint Lehigh-Hahnemann committee will, in the student's third year, recommend to Hahnemann Medical College up to ten of the candidates based on academic achievement, maturity, and a sincere desire for primary-care medicine. It should be emphasized that admission to Lehigh as a candidate in this Lehigh-Hahnemann program does not imply automatic admission to Hahnemann Medical College. Those of the group who choose not to continue or who are not admitted to Hahnemann at the end of the three-year curriculum still may continue in the traditional premedical program, may select other health profession fields, or may complete a biology, chemistry or alternate degree.

Students selected to enter Hahnemann spend their fourth academic year (first medical year) in the basic sciences core curriculum, including anatomy, biochemistry, physiology, microbiology, pharmacology, pathology, clinical science and behavioral problems. The fifth year in the joint program is spent in clinical rotations through which students learn the elements of clinical medicine through intensive clerkships in each of the major divisions of medical practice: medicine, surgery, obstetrics and gynecology, psychiatry, and pediatrics.

The sixth year is an advanced clinical basic science exposure in which intensive correlative study applies the fundamental scientific principles to clinical medicine. The seventh and final year is conducted totally in the Lehigh Valley area utilizing local physicians and local medical facilities and further acquaints the student with the challenges of primary-care medicine. The program results in the awarding of a doctor of medicine from Hahnemann Medical College and a bachelor's degree from Lehigh.

Bachelor of Arts in Premedical Science

The suggested sequence for the bachelor of arts in premedical science is as follows:

Year 1: Lehigh (fall) (16 credits)
Biol 21, 22 (4)
Math 41 (3)
Engl 1 (3)
elective (Humanities) (3)
elective (Social Science) (3)

Year 1: Lehigh (spring) (17 credits)
Chem 21, 22 (5)
Math 44 (3)
Engl 2, 4, 6, 8, or 10 (3)
elective (Humanities) (3)
Hist 8 (3)

Summer 1: Lehigh (9 credits)
Chem 51, 53 (4)
Chem 52, 54 (5)

Year 2: Lehigh (fall) (17 credits)
Phys 11, 12 (5)
Biol 28 (3)
Math 42 (3)
elective (Humanities) (3)
elective (Social Science) (3)

Year 2: Lehigh (spring) (16 credits)
Phys 13, 14 (4)
Chem 31 or 194 (3)
elective (Humanities) (3)
elective (Social Science) (3)
Free elective (3)

Year 3: Lehigh (fall) (16 credits)
Biology elective (3)
Biochemistry/biophysics elective (3)
elective (Humanities) (3)
elective (Social Science) (3)

Year 3: Lehigh (spring) (15 credits)
Biology elective (3)
Biochemistry/biophysics elective (3)
elective (Humanities) (3)
elective (Social Science) (3)
Free elective (3)

Bachelor of Science in Chemistry

The suggested sequence for the bachelor of science in chemistry is as follows:

Year 1: Lehigh (two semesters) (33 credits)
Chem 21, 22 (5)
Math 21 (4)
Engl 1 (3)
Biol 21, 22 (4)
Hist 8 (3)
Eco 1 (4)
Math 22 (4)
Engl 2, 4, 6,. 8, or 10 (3)
Chem 31 (3)

Summer 1: Lehigh (13 credits)
Chem 51, 53, 57 (organic) (5)
Chem 52, 54 (organic) (5)
General Studies requirement (3)

Year 2: Lehigh (two semesters) (33 credits)
Phys 11, 12 (5)
Chem 323, 234 (analytical) (4)
Chem 358 (organic) (3)
Biol 28 (genetics) (3)
General Studies requirement (6)
Chem 194 (physical) (3)
Math 23 (4)
Phys 21, 22 (5)

Year 3: Lehigh (two semesters) (30 credits)
General Studies elective (3)
Chem 384 (advanced chemical experimentation) (2)
Chem 338 (advanced analytical) (1)
Chem 307 (advanced inorganic) (3)
Chem 191 (physical chemistry) (3)
Chem 371/372/377 (biochemistry) (9)
Biology and/or biophysics elective (9)

Lehigh-Medical College of Pennsylvania

In cooperation with the Medical College of Pennsylvania, Lehigh offers an accelerated six-year program which enables selected students to earn both the bachelor of arts degree in premedical science and the M.D. degree after a minimum of six years of study at the two institutions. The program was initiated in the fall of 1974, and approximately fifteen students are admitted each year.

The program as outlined below shows two academic years and two summers at Lehigh, during which time ninety hours of credit are earned toward the 120 required for the baccalaureate degree. Students entering Lehigh with sufficient advanced placement credit may minimize or eliminate the second summer session. The next four years are spent in the regular program of medical education at the medical college. After the first two years at the medical college studnts will have acquired the necessary additional credit hours for the baccalaureate degree.

During the first two years at Lehigh, students are expected to make satisfactory progress in the academic areas as well as in the more subtle task of personal growth in those attributes ultimately needed as a physician. Seminars are conducted on campus by Medical College of Pennsylvania faculty, and students are assigned to MCP faculty advisers. MCP receives student grades and monitors student progress through regular counseling sessions and feedback from Lehigh staff.

MCP has specifically avoided setting arbitrary standards for peformance in order to encourage students to pursue the more difficult courses and to range into new academic and extracurricular areas appropriate to the student's academic and personal growth.

The medical college reserves the right to withdraw an offer of acceptance if academic or personal concerns cause the college to question a student's ability to function as a physician. The college also reserves the right to require that a student spend additional time at Lehigh if the medical college feels that this is necessary for the student's academic or personal maturation.

Experience with the program to date indicates that such action is rarely necessary. In addition, the student may elect to take additional time at Lehigh prior to matriculation at the medical college if he or she feels that this would be beneficial. Should this occur, the student would be eligible to defer matriculation at medical school for a period of time agreed to by the student and the medical college.

Application for admission to the program must be made through Lehigh's office of admission. Admission is based on SAT scores (minimum combined score of approximately 1300), scholastic achievement, maturity, and motivation for medicine. Preference is given to residents of Pennsylvania.

Interviews are not required at Lehigh, but students are encouraged to make arrangements to come to campus to have an interview and to become better acquainted with Lehigh and the special features of the program.

Year 1: Lehigh
Chem 21-22 (5)
Math 21 (4)
Engl (3)
elective (Humanities) (3)
elective (Social Science) (3)
Biol 21-22 (4)
Math 22 (4)
Engl (3)
elective (Humanities) (3)
elective (Social Science) (3)

Summer 1: Lehigh
Chem 51-53 (organic) (4)
Chem 52-54 (organic) (5)
elective (Humanities) (3)

Year 2: Lehigh
Phys 11-12 (5)
Math 23 (4)
elective (Biology) (3)
elective (Humanities) (3)
elective (Social Science) (3)
Phys 13-14 (4)
Chem 31 or 194 (chemical equilibrium or physical) (3)
Biol 28 (genetics) (3)
elective (Humanities) (3)
elective (Humanities) (3)
elective (Social Science) (3)

Summer 2: Lehigh
elective (Social Science or Humanities) (3)
elective (free) (3)

Honors Programs

The several honors programs are designed to permit students who demonstrate unusual academic ability and interest to explore more widely than their curricula would normally allow and to engage in independent study and research.

Departmental Honors

These programs give highly motivated students the opportunity to study in the major field more intensively and in greater depth than the standard program provides.

The precise nature of the program for each student is determined by the major department. The program may include:

a. Unscheduled work or independent study (up to four hours per semester in the junior year; up to six hours per semester in the senior year).

b. Waiver of graduate standing: undergraduate students will be permitted by petition to the Graduate School to register in a 400-level course for which they have the necessary prerequisites under the conditions that they: 1. have maintained a 3.00 average in each of the two semesters prior to the date of the petition, and 2. will carry a course load not to exceed fifteen hours unless four-credit courses, military science or aerospace studies and the like raise it to seventeen hours maximum.

c. Honors thesis or project. Candidates for departmental honors announce to their major adviser during the junior year, or no later than the beginning of the senior year, their intention to work for departmental honors. Each major adviser submits to the registrar, the dean of the college, and the chairman of honors programs, no later than the close of registration of each fall semester, the names of seniors who are working for departmental honors in the particular major.

The names of those students who attain departmental honors will be announced at the graduation exercises.

College Scholar Program

The College Scholar Program offers the qualified student a unique opportunity for maximum enhancement of critical faculties, abilities and intellectual interests. This end is

achieved through a structured program conforming to exceptional standards of breadth and rigor.

Undergraduates in the College of Arts and Science may apply for acceptance into the program at any time during the college career. An application is made to an honors committee, and acceptance is governed by the performance of the student to date and the committee's estimate of the likelihood that he or she will be able to fulfill the requirements of the program.

In order to be graduated with the designation "College Scholar," a student must fulfill the requirements and achieve a cumulative average of 3.5.

Each student is required to have an individually structured program which must be approved by the director. No course taken pass/fail may be used to satisfy the requirements. The requirements follow.

Area of concentration

The major. Departmental or interdepartmental. The academic level expected of candidates in the area of concentration can be attained by satisfactory completion of courses such as those at the 400 level, independent study, etc.

Thesis. The student takes a certain number of hours in independent study or thesis courses, culminating in a thesis or research report. This is read and rated by an ad hoc committee of three faculty, one of whom must be from outside the department or departments in which the student is doing major work.

Comprehensive. There is to be a comprehensive examination in the area of concentration; it may be written, oral or both. A committee in charge of the examination includes at least one person from a department other than that (or those) in which the student is doing major work.

Distribution requirements

English. English 1 and either 2, or 10, 14, 16.

Language. Proficiency in a classical or modern foreign langauge sufficient to complete the work of the fifth semester in any 3-3-3-3-3 sequence of credit hours; in a 4-4-3-3 sequence, completion of the fourth semester is required. There is no restriction on the language acceptable.

Mathematics. One course from among: Math 21, 31 or 41.

Natural Science. Four courses chosen from two of the following areas: astronomy, biology, chemistry, geology, physics and psychology. At least one of these courses shall be in chemistry or physics, and at least one of the four courses shall include the accompanying laboratory course.

Social Science. Four courses chosen from the areas of archaeology, economics, government, history, international relations, psychology, social relations and urban studies. At least one must be in economics and one in history.

Humanities. Four courses chosen from the areas of drama, fine arts, literature (English and advanced courses in classical and modern foreign languages), music, philosophy and religion studies. At least one of these courses must be in philosophy or religion studies, one in literature, and one the creative arts (theater, music and art and architecture).

Note: Each of the last three requirements is stated in terms of *areas*, not *departments*, in recognition of the fact that not all humanities courses are offered in the departments whose names appear under "Humanities," not all historical courses are offered by the history department, not all philosophy courses by the philosophy department, etc.

The committee makes the decision, in consultation with the appropriate departments, under which rubric a specific course may be counted. It also is empowered to admit what substitutions it deems wise.

Honors seminars

Two seminars, normally to be taken during the sophomore or junior year. A study of major ideas which have dominated Western thought.

Electives

Humanities Perspectives on Technology Program

The Humanities Perspectives on Technology (HPT) program is a broad-based effort on the part of Lehigh faculty, especially from the College of Arts and Science, to foster undergraduate courses concerned with the interrelationships between technological advance and the quality of human life.

The HPT program offers a minor in "Technology and Human Values," consisting of eighteen hours of course credit drawn from a variety of departments. For a full description of the program see page 158.

Law and Legal Institutions Minor

This program, based in the College of Arts and Science, is designed to foster interdisciplinary cooperation with the faculties of the other colleges in the university. This minor program is open to students from all three undergraduate colleges. Although the program may be of particular interest to some pre-law students, it is not intended to be viewed as the preferred pattern for those hoping to attend law school.

The eighteen-hour program stresses the systematic analysis of contemporary legal institutions, coupled with an examination of their historical antecedents, especially those in the Anglo-American common law tradition. All participants in the program are required to develop basic skills of logical analysis, and during their senior year they undertake supervised legal research under the direction of one or more of the participating faculty members.

The program also is designed to expose students to both public and private law, and to courses using the traditional case method as well as those using alternative modes of analysis, e.g., the historical methods.

Exceptions to the arrangements described below may be approved by the coordinator of the program.

Required courses (9 credit hours)

Law 11	Introduction to the Law (3)
Phil 13	Practical Logic (3)
Special Topics (3)	

This research course of one semester's duration is taken during the student's senior year. The field is designated by the student, e.g., law, philosophy, journalism, history, international relations, or government, depending upon the faculty member(s) with whom the student is working.

Elective courses (9 credit hours required with at least one course in both categories)

Law 201	Business Law (3)
Govt 351	Constitutional Law (3)
Govt 352	Civil Rights (3)
Govt 354	Administrative Law (3)
IR 361	International Law (3)
Journ 122	Law of the Press II (3)
Phil 221 (Law 221)	Sex-Discrimination and the Law (3)

Category II-Non-Case Method

Govt 53	Law and Politics (3)
Hist 347	English Constitutional and Legal History to 1485 (3)
Hist 348	English Constitutional and Legal History Since 1485
IR 362	International Law (3)
Phil 122	Philosophy of Law (3)

Policy of Flexibility

There is flexibility in undergraduate curricula at Lehigh, intended to take into consideration the changing interests and needs of students.

For example, in the College of Engineering and Physical Sciences, each department provides a range of hours needed for graduation to provide flexibility to the student who wants to take more or less work outside the department. This flexibility extends to late changes of major or even a change in college without loss of credits.

Graduate students may find their interests shifting to new fields as they progress in their educational program or they may wish to strengthen their preparation for a career by advanced study in a related field or in an interdisciplinary program. The policy of the Graduate School is to provide as much flexibility as possible to students who wish to change to a new but related field of study after either the baccalaureate or the master's degree.

Students should consult with the director of their previous program and with the director of the new field in order to establish the course program that will remedy any deficiencies in background and will be of maximum value.

Students who have just completed a bachelor's degree in one field at Lehigh may find it advantageous to study for a graduate degree in a related field under a new group of the faculty without losing the continuity and familiarity provided by staying the Lehigh campus.

Pre-Law Programs

Lehigh has a strong pre-law tradition. In keeping with the policy of the Association of American Law Schools, the university does not have any prescribed prelaw program.

Lehigh students have been successful in attaining entrance into law schools from diverse curricula within all three of the undergraduate colleges.

An active student-run Pre-Law Society brings members of the legal profession and law school personnel on campus for discussion meetings and continuously provides information about law school opportunities.

Law-related courses, some of which rely on the casebook method, are provided by both the College of Arts and Science and the College of Business and Economics. In the former, for example, there is a course in Law of the Press through the journalism division. In the latter, courses in law are regularly offered by the department of accounting and law.

Counseling is available to prospective pre-law students on a continuous basis from freshman orientation through the law school application process in the senior year. Counselors are members of the pre-law advisory committee, composed of faculty members of both colleges. Students are urged to consult members of the committee as early as possible in their academic careers.

Details on a Law and Legal Institutions minor program are found on pages 50 and 51.

Presidential Prizes

Lehigh University offers each year ten Presidential Prizes valued at $4,000 each, for four years of college. These are reserved for entering freshmen and are awarded on a competitive basis, irrespective of financial need. Each prize provides $500 per semester, credited toward tuition, in any of the three undergraduate colleges of the university.

The prizes, once assigned, continue in force for the full four years of the student's residence at Lehigh University, unless the holder fails to meet the normal scholastic requirement of a 3.00 average or better and the qualifications of a good citizen. In rare instances this requirement may be waived upon unanimous vote of the prize committee and the approval of the president. The prize is based strictly on merit, without regard to financial need.

In order to compete for one of the prizes a freshman candidate must:

1. Be a successful candidate for admission in any of the three undergraduate colleges, Arts and Science, Business and Economics, or Engineering and Physical Sciences, with evidence of promise of high academic achievement.

2. Submit a separate prize application providing more detailed information regarding any important piece of creative work, independent study, evidence of leadership potential, notable accomplishments which do not appar on the regular record submitted for admission, or the promise of making an extra-ordinary contribution to the life of Lehigh. Thus the applicant may show high achievement in such diverse areas as the arts, the sciences, athletics, original scholarship, literature, or music.

3. Be interviewed by a member of the Lehigh faculty, generally a member of the prize committee. If distance prohibits a campus visit, the interview may be with a selected alumnus or alumna.

All candidates for admission are automatically eligible to compete for one of these prizes and will be so considered. A preliminary selection of finalists is made in January when prize applications are distributed and interviews conducted. Winners are announced in April. It is possible to receive a Presidential Prize and also qualify for other forms of financial aid. The Financial Aid Form, however, is not required to be considered for a prize.

Prizes will be made in the order of the contestants' ratings on such weighted factors as secondary school scholastic record, evidence of effective leadership and distinguished group service, character and personality, and performance in the College Board tests.

The prizes follow the general plan of the prestigious academic scholarships typified by the Rhodes Scholarships. Geographic location will play some part in the final selection. Men and women students are equally eligible.

Provisional Courses

A program of provisional courses enables instructional departments to introduce courses temporarily within a semester. Provisional courses are normally either experimental courses or courses based on contemporary social and scientific issues. They may later become part of the regular curriculum if proven successful.

Provisional courses can be taken on a pass/fail basis. Since most courses are not developed in time to be included in course listings, they are identified with a 97-98 number and are incorporated in the registrar's offocial semester roster for a maximum of two semesters.

A sample listing of provisional courses includes: "Political Violence"; "Historical Sites Administration"; "Dynamics of Relations Between Developing Countries";

"Indian Philosophy"; "Paganism and Christianity in the Roman Empire"; "Literary Approaches to Science"; "Sex Discrimination and the Law", and "Philosophical Games".

Research Initiates

Undergraduates who seek or are considering a career involving research are encouraged to investigate the possibility of becoming research initiates in their junior or senior years.

Research initiates are attached to specific research projects in progress on the campus, serving as assistants to advanced graduate students or to staff members. They assist in experiments, sit in on project conferences and if occasion permits, undertake small side investigations appropriate to their competence.

The research initiate may receive degree credit by registering for unrostered work for up to six hours per semester. In a few cases, a nominal stipend may be paid for the work, and summer employment is occasionally available. The student should explore the possibility of becoming a research initiate with the curriculum adviser.

Special Summer Opportunities

In addition to the normal opportunities offered to graduate and undergraduate students in summer school, there are also opportunities for both remedial and accelerated work.

Special programs and field work activities are available for intense in-depth educational experiences. Examples of these include the Robert A. Taft Institute of State and Local Government, Field Study in Geology (conducted in Wyoming and Idaho) and the Civil Engineering Survey Field Course (conducted in the Pocono Mountains). Short courses and workshops are offered in a wide variety of subject areas.

Interested students should consult with their curriculum director or the director of summer session. A publication listing the total summer program is available every spring.

Study in Foreign Countries

To the extent that their courses of study permit it, students maintaining a "B" average or better are encouraged to consider spending one or two semesters of study in acceptable "junior-year abroad" programs or as regularly enrolled students in a foreign university.

Among the accepted programs are New York University in Spain, Smith College and Wayne State University in Germany, Sweet Briar College and Hamilton College in France, and Dickinson College at Bologna, Italy. Students declared qualified for acceptable foreign study remain eligible to apply for financial aid from Lehigh University.

To emphasize further its interest in international study, the university has provided funds to cover transportation, tuition, and living expense stipend for a graduating senior desiring to study abroad.

The university, through the department of modern foreign languages, offers scholarships for qualified students to participate in approved programs of study abroad.

Students interested in study abroad should consult G. Mark Ellis, Maginnes Hall.

The Washington Semester

Opportunity is available each year for several selected juniors or seniors to spend either the fall term or spring term to study in the nation's capital through cooperation with American University in Washington, D.C. Lehigh University is a member with sixty other colleges and universities.

The students enroll at Lehigh but spend the semester in residence at American University with the students from the participating colleges.

The curriculum of the Washington Semester program consists of national government seminars, an internship, and a written project. Besides the Washington Semester program itself, the student may choose other program offerings such as the Urban Semester, Economic Policy Semester, Foreign Policy Semester, International Development Semester, Justice Semester, and American Studies.

Should a student withdraw from either the Washington or Harrisburg program, the student will be held responsible for the costs incurred through the program. Costs will be calculated on the basis of the university's customary refund policy.

Recognition of Achievement

Student prizes and awards are announced at commencement exercises on Founder's Day, the second Sunday in October, and on University Day in May or June. A description of prizes and awards follows.

Alumni Prizes. Funds are provided by the alumni association for the annual award of four prizes of $25 each. Two prizes are awarded to the highest-ranking juniors in the College of Engineering and Physical Sciences, one to the highest-ranking junior in the College of Arts and Science, and one to the highest-ranking junior in the College of Business and Economics.

Medal of the Philadelphia Chapter, American Institute of Chemists. This medal is awarded to the academically highest-ranking senior majoring in chemistry or chemical engineering.

American Society for Testing Materials Student Membership Prize. The ASTM awards each year four student memberships to students who in their junior year have demonstrated interest and meritorious work in the engineering courses which are related to the ASTM.

Bethlehem Fabricators Award. This tuition award is made to the junior who has shown the most improvement in academic achievement over previous years.

The Robert W. Blake Memorial Prize. This prize is awarded annually at Founder's Day exercises to a freshman, upon completion of one year of studies in the College of Arts and Science, who is recommended by the college faculty as the most outstanding in high scholastic achievement and in promise of worthy leadership.

Nelson Leighton Bond 1926 Memorial Award. This award is made to an outstanding sophomore on the basis of character, leadership and scholastic achievement but not financial need.

The John B. Carson Prize. An annual prize of $50 was established by Mrs. Helen Carson Turner, of Philadelphia, in memory of her father, John B. Carson, whose son, James D. Carson, was a graduate of the civil engineering curriculum in 1876. It is awarded to the senior in civil engineering who shows the most marked excellence in professional courses.

The William H. Chandler Prizes in Chemistry. Four annual prizes of $25 each, one in each class, for excellence in the chemistry and chemical engineering curricula were established by Mrs. Mary E. Chandler, of Bethlehem, widow of Dr. William H. Chandler, who was professor of chemistry at Lehigh from 1871 until his death in 1906.

The N.I. Stotz and D.E. Rickert Choral Cup. The choral cup provided by Norman I. Stotz, Jr., '53, and Donald E. Rickert, '53, is awarded to the outstanding senior participating in the choral organizations of the music department.

Class of 1904 Scholarship Award. The award is presented to an outstanding member of the junior class on the basis of character, scholarship, qualifications indicating promise of future leadership, and extracurricular activities.

The R.K. Burr and J.D. Kirkpatrick Concert Cup. The concert cup provided by Richard K. Burr, '53, and J. Donald Kirkpatrick, '55, is awarded to the outstanding senior(s) participating in the band or other instrumental organizations of the music department.

The Cornelius Prize. The Cornelius Prize of $25, established by William A. Cornelius, M.S. '89, and endowed by a bequest by his widow, Mrs. Eleanor R. W. Cornelius, is awarded annually to the senior student in mechanical engineering who is judged to have profited most by opportunities at Lehigh. The award is based 70 percent on scholarship, 20 percent on attainment in general culture, and 10 percent on development in personality. To be eligible for the award, a student's scholastic standing must be in the top quarter of the class in the College of Engineering and Physical Sciences.

The Philip Francis du Pont Memorial Prize in Electrical Engineering. The Philip F. du Pont Memorial Prize Fund was established in 1929 by L.S. Horner, EE '98. The annual income of this fund is awarded each year in the way of prizes, two-thirds to the highest randing senior and one-third to the second highest ranking senior in electrical engineering.

Jonathan B. Elkus Freshman Music Cup. This is awarded each year to a full-time freshman on the basis of membership in marching and concert band, over-all music ability, and demonstrated leadership and exceptional psyche.

Fraternity Alumni Advisory Council Scholarship Improvement Award. This trophy is awarded to the fraternity chapter whose scholastic avaerage for the year is most improved over the average for the previous year.

Gipson Institute Undergraduate Essay Prize. This prize of $200 is awarded for the best undergraduate paper dealing with an eighteenth-century topic.

The Gold-Hansen Trophy. Proveded by Stephen R. Gold and Robert A. Hansen, both members of the class of 1960, the trophy is awarded to a student of at least four semesters' standing with the Lehigh University Band who has shown outstanding merit in other ways than musical or marching performance.

Malcolm J. Gordon, Jr., Physics Prize. An annual award of $40 is made to the highest-ranking sophomore majoring in physics with some extracurricular activity.

The Bill Hardy Memorial Prize. An annual award of $100 is given by Mr. and Mrs. C. Edson Hardy in memory of their son. The recipient is the junior who most nearly reflects the qualities that typified Bill Hardy, who was outstanding in many activities, academic and otherwise.

Haskings and Sells Foundation Award. An annual award of $500 is awarded to that accounting student in the College of Business and Economics or the College of Arts and Science who after three years has demonstrated excellence in scholarship, professional potential, extracurricular activities, and moral character.

Donnel Foster Hewett Award. This is awarded to the senior in geology or geological sciences who has demonstrated the greatest potential for a professional career in the earth sciences.

The Harold J. Horn Prize. The heirs of Harold J. Horn, EE '98, established a fund, the income of which is used in the award of a first and second prize of $40 and $20 respectively, for the two highest-ranking juniors in electrical engineering.

Kappa Alpha Glee Club Senior Cup. The cup is awarded to a senior for outstanding service to the Lehigh University Glee Club.

The Andrew Wilson Knect III Memorial Award. This award is made each year to the member of the mechanical engineering class graduating in May or June who has exhibited the greatest potential for applying technical training to practical application. The award is an engraved designed medallion.

Kodak Scholar Awards. These awards are made to second-semester freshmen each year who plan to major in engineering fields other than civil engineering. They cover 75 percent of tuition cost.

Arnie Lasser Award. This award is made to an outstanding undergraduate athlete in football or wrestling from the New York metropolitan area, regardless of need.

Merck Index Award. A copy of the Merck Index is awarded by Merck and Co., Inc., to a senior in chemistry who is an outstanding student, who has been active in student society affairs and who has promise of a successful career in chemistry in the judgment of the faculty of the chemistry department.

The Elizabeth Major Nevius Award. Established by Walter I. Nevius, EE '12, "in living memory of his wife, who profoundly admired young men of diligence, intelligence, aggressiveness and sterling character," the award of $500 is made annually to that senior enrolled in any five-year combination curriculum leading to two baccalaureate degrees who, upon completion of his or her first four years at Lehigh University and upon graduation with his or her class, shall be adjudged the most outstanding of the seniors completing work for their first baccalaureate degree and continuing to a second baccalaureate degree at Lehigh University, judged upon the basis of leadership, citizenship and scholarship.

Pat Pazzetti Award. In honor of Vincent Joseph "Pat" Pazzetti, Jr., '15, to a Lehigh football player of outstanding ability.

The Pennsylvaia Institute of Certified Public Accountants Prize. This plaque goes to the senior in the College of Business and Economics majoring in accounting who is outstanding in academic achievement and leadership.

Phi Sigma Kappa Scholarship Cup. This scholarship cup, awarded to the fraternity in the Interfraternity Council having the highest scholastic average for the preceding year, becomes the permanent property of the fraternity winning it for three successive years. The cup was provided by an alumnus of the Nu Chapter of Phi Sigma Kappa in 1923. Cups are provided by the local chapter.

Leonard P. Pool Memorial Award. This award of $3,000 is made annually to a junior or senior student exhibiting entrepreneurial talents.

The Allen S. Quier Prize in Metallurgy. An annual prize of $15 has been provided by the daughters of the late Allen S. Quier in memory of their father, to be awarded to the senior who is adjudged by the staff of the metallurgy and materials engineering to have made the most progress in that curriculum. While high scholastic standing is a requisite, the prize is awarded on the basis of progressive achievement in scholastic work, rather than an average rating.

Bosey Reiter Leadership Cup. This award is given to the student whose leadership contributes primarily to the best interests of the university. Leadership is defined chiefly as moral character and combines intellectual ability and common sense. High scholarship and athletic achievements are included as cases of leadership, but neither is necessary or sufficient alone.

Robert Ridgeway Senior Prize. This prize is awarded to the senior in the College of Engineering and Physical Sciences with the highest cumulative average.

Col. Edward W. Rosenbaum Award. The award, in honor of Robert Rosenbaum, '17, is awarded each year to recognize the outstanding senior aerospace studies student.

Scott Paper Company Foundation for Leadership Award. This award is made each year to a sophomore student who must have achieved a high level of scholarship and noteworthy success in extracurricular activities and, in addition, should possess a balance of desirable personal qualities such as intelligence, integrity, strong moral character, loyalty, enthusiasm, physical vigor, persuasiveness and social consciousness. Great weight is to be given to characteristics and abilities which sould best equip the individual to succeed as a leader in industrial or commercial activities.

The Senior Band Plaque. The plaque was established by the seniors on the executive committee of the Lehigh University Band to honor a member or members of the senior class of the band who have given outstanding performances in both marching and concert seasons for four years and who have not served in a major administrative capacity in the band.

T. Edgar Shields Band Cup. This is awarded annually to the student who has made the greatest musical contribution to the band.

T. Edgar Shields Glee Club Cup. This is awarded annually to the student who has made the greatest musical contribution to the Glee Club.

Sigma Xi Undergraduate Research Award. An award of $50 and associate membership in the society is made to an undergraduate student by the chapter executive committee from departmental nominations. The basis of the award is research potential and demonstrated achievement in research.

Spillman and Farmer Architectural Award. An architectural book and $15 is awarded to the student(s) creating the outstanding architectural or environmental design in the architecture classes of the department of art and architecture.

Alan H. Stenning Award. A sum of $50 is awarded each year to a senior mechanical engineering or mechanics student for excellence in an undergraduate engineering project.

Bradley Stoughton Student Award. This award is given to an outstanding senior in the metallurgy and materials engineering department. It consists of a certificate and $25.

Thornburg Mathematics Prize. This prize is made possible through a bequest by the late W.P. Tunstall, '03, in honor of the late Professor Charles L. Thornburg. The prize, consisting of a credit slip for $40 to purchase books in the field of mathematics or allied disciplines at the Bookstore, is awarded to the senior with the most outstanding record in an advanced course in mathematics.

Trustees' Scholarship Cup. The trustees have provided this cup which is awarded for one year to the living group having the highest scholarship average for the preceding year. The cup becomes the permanent property of any living group winning it for three successive years.

University Service Award. This award is given annually to the senior who has been adjudged to have contributed most during his or her career at Lehigh to promote student body unity, campus cooperation for worthy objectives, and loyalty to the alma mater. It is expected that the student selected shall be of sound character and satisfactory scholarship.

John R. Wagner Award. This is awarded each year to the junior student in mechanical engineering whose scholastic record is the highest in his or her class in the freshman and sophomore years and whose character and life purposes are deemed deserving and worthy.

Wall Street Journal Award. This is awarded each year to a senior finance major primarily on the basis of scholarship.

William Whigham, Jr., Memorial Prize. This is awarded annually to the top-ranking freshman in engineering, based on accumulative average of the first two semesters.

The Elisha P. Wilbur Prizes. A fund was established by the late E.P. Wilbur, trustee from 1872 until 1910, for distribution in prizes as the faculty might determine. The income from this fund is used to provide two awards, as follows:
Wilbur Mathematics Prizes. A first and second prize of $50 and $25 respectively to be awarded annually to the two highest-ranking freshman engineers in mathematics, as recommended by the department of mathematics.
Wilbur Scholarship Prize. This prize of $200 is awarded annually to the sophomore with the best semester average for the sophomore year.

The Williams Prize in Creative Writing. A prize of $100 is awarded annually to the author for a meritorious short story, play, or poem submitted by a Lehigh undergraduate.

The Williams Prize in Dramatics. A prize of $100 is awarded annually to a Lehigh undergraduate whose interpretation of a role in a production of the Mustard and Cheese Drama Club is judged the most outstanding.

The Williams Prizes in English. The late Professor Edward H. Williams, Jr., class of 1875, established prizes for excellence in English composition and public speaking. The prizes are awarded by the faculty on the recommendation of the department of English, as follows:
Freshman Composition Prizes. A first prize of $100, a second prize of $75, and a third prize of $50 are awarded for the three best compositions submitted by freshmen as required work in their English courses.
Sophomore Composition Prizes. A first prize of $100, a second prize of $75, and a third prize of $50 are awarded for the three best compositions submitted by sophomores as required work in their English courses.
Junior Composition Prizes. A first prize of $100, a second prize of $75, and a third prize of $50 are awarded for the three best essays submitted by juniors as part of the required work in their courses in English.

The Williams Prizes in Extempore Speaking. A first prize of $100 and a second prize of $50 are awarded annually to freshman of regular standing who excels in a contest in extempore speaking. A first prize of $100, a second prize of $75, and a third prize of $50 are awarded annaully to the winners in a contest in extempore speaking for sophomores, juniors and seniors. Winners of first prizes are not eligible to compete in subsequent years.

The Williams Prize in Interpretive Reporting. A prize of $100 is awarded annually to a Lehigh undergraduate for meritorious reporting, published or unpublished, intended to interpret the meaning of events or developments which are significant in the life of the university.

The Williams Prizes in Intramural Debating. Sums totaling $300 are awarded annually as prizes in intramural debating. Students engaged in this activity are organized under the direction of the department of English into teams which compete in a series of debates. The sum of $200 is divided equally between the two members of the first-place team and the sum of $100 is divided equally between the two members of the second-place team. Winners of first-place prizes are not eligible to compete in subsequent years.

The Williams Prize in Varsity Debating. A prize of $100 is awarded annually to a Lehigh undergraduate whose performance in intercollegiate debating is judged the most outstanding.

The Williams Senior Prizes. These prizes are awarded by the faculty on the recommendation of the committee on Williams Prizes.
1. First prizes of $200, second prizes of $100, and third prizes of $50 are awarded annually to each of the five fields of economics, English, philosophy, psychology, and history and government for dissertations submitted by regular members of the senior class on or before April 15.
2. The committee on Williams Prizes publishes, before the close of the academic year, a list of recommended subjects for dissertations;

but a senior may submit a dissertation upon any other subject in the respective field if the subject has received the approval of the committee.
3. Each senior entering the competition shall submit to the committee his or her choice of subject and plan of work by November 15.
4. The awards are made by the faculty upon recommendation of the committee, but no award is made if in any case a dissertation does not meet the standards of merit established by the committee. This standard includes such points as excellence in thought, plan, development, argument, and composition.

The Theodore B. Wood Prize. A prize of $50 is awarded under the terms of the will of the late Theodore Wood to the mechanical engineering student who has made the greatest scholastic improvement during the first two years of the college course.

Prizes Awarded by Student Organizations

These prizes include the following:

Alpha Epsilon Delta Award. Alpha Epsilon Delta places the name of the premedical biology freshman with the highest cumulative average on a plaque in the department of biology.

Alpha Kappa Psi Key. The Alpha Sigma Chapter of Alpha Kappa Psi, a professional fraternity in commerce, awards annually the Alpha Kappa Psi scholarship key to the senior pursuing a degree in the College of Business and Economics who has attained the highest scholastic average for three years of collegiate work at Lehigh.

The Alpha Pi Mu Prize. The Alpha Pi Mu honorary fraternity in industrial engineering awards each year an industrial engineers' handbook to a high-ranking sophomore with demonstrated interest in the industrial engineering curriculum.

American Chemical Society Award. The Lehigh Valley Section of the American Chemical Society awards a membership in the society and a subscription to a journal of this society to the highest-ranking junior in chemistry or chemical engineering.

American Soceity of Civil Engineers Prize. The Lehigh Valley Section of the American Society of Civil Engineers offers a prize of a junior membership in the society to the outstanding senior in civil engineering holding membership in the student chapter.

American Society of Mechanical Engineers Associate Membership Prize. The Anthracite-Lehigh Valley Section of the American Society of Mechanical Engineers awards to an outstanding member of the Lehigh University Student Section ASME an associate membership for one year in the parent society.

Alpha A. Diefenderfer Award. In recognition of Professor A. A. Diefenderfer's long service as faculty adviser to the organization, the Lehigh University Chemical Society established this award for the highest-ranking senior in analytical chemistry. Each winner is presented with an engraved certificate, and the name is inscribed on a plaque displayed in the chemistry building.

Eta Kappa Nu Prize. The honorary fraternity in electrial engineering awards a handbook in electrical engineering to the highest-ranking freshman in electrical engineering.

Pi Lambda Phi Journalism Award. This is awarded to an undergraduate for outstanding editorial or business achievement in the field of publications. The trophies are made available by the local chapter of Pi Lambda Phi social fraternity.

Pi Tau Sigma Prize. The honorary fraternity in mechanical engineering awards each year a mechanical engineers' handbook to the highest-ranking sophomore in mechanical engineering.

William H. Schempf Award. This award is made annually to the freshman who has shown outstanding ability and interst beyond the requirements of a normal freshman bandsman. It is made in honor of a former head of the music department by the Beta Sigma chapter of Theta Chi social fraternity.

John S. Steckbeck Award. This award is presented annually to the most outstanding woman freshman athlete in good academic standing.

Tau Beta Pi Prize. The honorary engineering fraternity awards each year a slide rule or other prize of equivalent value to the engineering sophomore having the highest scholastic average.

Protective cloaks envelop the passengers in this 1904 Model L Packard. The automobile, the first to introduce the unique Packard radiator outline, had just completed the fourth 670-mile testing trip to Chicago.

IV. Advanced Study / Research

Since the university began in 1961 to encourage the growth of its Graduate School, resources available for graduate study have greatly increased. Considering the graduate program to be composed of formal course instruction and a research experience, the university has developed means to enable students fruitfully to pursue such work.

Research provides a principal method of training and education at an advanced level by concentrated study on a specific problem under close direction of senior faculty members. Such study in theory and experiment assured that classroom teaching is up-to-date; thus research, classroom and laboratory instruction complement each other.

Lehigh has numerous special laboratories to facilitate such research in the sciences and engineering. These laboratories are located in Fritz Engineering Laboratory, which houses the civil engineering department and the world's second-largest universal hydraulic testing machine; Whitaker Laboratory, completed in 1965 for the chemical and metallurgical engineering departments; Sinclair Laboratory, completed in 1970, for surface chemistry and coatings research; Packard Laboratory, for electrical engineering, mechanical engineering, mechanics, and the Computing Center; Williams Hall, for biology, geological sciences, psychology, and the bioelectric research laboratory; the Physics Building; the chemistry complex, completed in 1975; Coxe Laboratory, for metallurgy and the electronic microscopy laboratory, and the Sherman Fairchild Laboratory for solid-state physics.

The university's Linderman Library is rich in the humanities and social sciences, including the rare book collection. The Mart Science and Engineering Library served the fields of engineering, mathematics and the natural and physical sciences. Resources of other libraries are available.

Under certain programs, Lehigh graduate students have access to facilities at industries in the area. Also, some of the major libraries of the country are within an hour's drive.

The university policy is to make its resources available to all faculty and students, including undergraduates, but graduate students dominate student usage of the more sophisticated laboratory facilities and library holdings.

One manifestation of the growth of graduate education at Lehigh has been the organization of interdisciplinary centers and interdepartmental projects and cooperation. Recent success with mission-oriented research using an interdisciplinary approach—that is, scientists and engineers working together on a basic problem—promises an interesting kind of graduate education.

Lehigh's interdisciplinary centers offer an opportunity to implement this new approach by directing continuous attention to a given group of problems, stimulating interest in their solution, and, finally, mobilizing the talent across the campus required for meaningful research. Besides organizing research, the centers create new courses relative to their research.

Although most graduate students find their interests served by programs available within a single department, some may elect to work in interdisciplinary areas, which reach into two

or more departments. Generally, each graduate student's program can be designed to fulfill his or her own particular interests, subject to the requirement that the field thus defined has scope and depth appropriate for an advanced degree regardless of whether its boundaries fall within a single department. Faculty do not regard departmental organization as a limit to the bounds of their scholarly interests.

The Graduate School

Robert D. Stout, *dean*

Graduate study was a part of the original plan of the university and was announced in its first register in 1866. More definite organization of the work along lines that are now generally accepted dates from 1883. Since that time the degrees of master of arts and master of science have been offered without interruption.

The degree of doctor of philosophy was also announced for a time and twice conferred. In the mid-1890s, this degree was withdrawn and doctoral work was not offered until 1936, when it was once more authorized by the trustees. In the same year the Graduate School was organized, with its own faculty. In 1960 a program of studies leading to the degree of doctor of education was offered. A doctor of arts program was begun in 1971.

The Graduate School, in certain areas, offers qualified students opportunity for intensive advanced study and for specialized training in methods of investigation and research, with a view to their development as scholars and independent investigators. The school also aims to serve the needs of teachers and prospective teachers in elementary and secondary schools by providing opportunities for advanced professional training, and by preparing them for administrative positions.

Major work leading to the master's degree may be taken in the following fields: applied mathematics, applied mechanics, biology, business and economics, chemical engineering, chemistry, civil engineering, computer science, economics, education, electrical engineering, English, geology, government, history, industrial engineering, information science, management science, mathematics, materials engineering, mechanical engineering, metallurgy, modern foreign languages and literature, molecular biology, physics, physiological chemistry, political science, psychology, polymer science and engineering, public administration, and social relations. Advanced degrees are not offered in the fields of art and architecture, classics, and international relations; students majoring in other fields may take collateral work in these fields from the list of courses acceptable for graduate credit.

Work leading to the doctor's degree is offered in the following fields: applied mathematics, applied mechanics, biology, business and economics, chemical engineering, chemistry, civil engineering, education, electrical engineering, English, geology, government, history, industrial engineering, information science, mathematics, mechanical engineering, metallurgy and materials engineering, molecular biology, physics, physiological chemistry, polymer science and engineering, and psychology.

Admission to Graduate Standing

A graduate of an accredited college, university, or technical institution is eligible for consideration for admission to the Graduate School at Lehigh University. Actual admission is subject to enrollment limitations in each department and is therefore competitive.

An application for admission to the Graduate School may be secured from the Office of Admission, Lehigh University, Alumni Memorial Building #27, Bethlehem, Pa. 18015. The candidate should file this application as far in advance as possible of the beginning of the semester when graduate work is planned, but in any event, at least ten days before the start of classes. In addition to the application the candidate should also request that each institution of higher learning which he or she has attended send directly to the office of admission a transcript of the academic record. An application fee of $20 will be charged.

A prospective graduate student is invited to communicate directly with the chairman of the department of interest. If a visit to the university is convenient, the department chairman or a representative may help the student work out a program.

The submission of Graduate Record Examination scores by a student applying for admission is urged. In the case of foreign students, the GRE scores must be submitted. For information about this examination, write to the Educational Testing Service, 20 Nassau St., Princeton, N.J. 08541. If a student is applying for admission to graduate work in education, scores may be submitted for either the Graduate Record Examination or the Miller Analogies Test. Candidates for graduate work in business administration may submit scores for the Graduate Management Admissions Test. In all three instances, test scores may under certain circumstances be required.

Foreign students are required to submit evidence of competence in use of English. Tests such as those administered by the International Institute of Education or the Educational Testing Service are suitable.

Admission to graduate standing permits the student to take any course for which he or she has the necessary qualifications. It does not imply admission to candidacy for a degree. Admission to candidacy for an advanced degree is granted in accordance with the provisions set forth below under the heading Degree Information.

A graduate student who is absent from the university for a semester or more must obtain the written approval of the chairman of the major department in order to be readmitted to graduate standing. If the student has not established a major, he or she must obtain the approval of the dean of the Graduate School.

Students of Lehigh University who are within a few hours of meeting the requirements for the bachelor's degree may, if given permission by the graduate committee, enroll for a limited amount of work for graduate credit.

Resident graduate student. A resident graduate student is one whose primary activity is work toward an advanced degree. The individual must be registered for at least nine semester hours of research and/or course work toward the degree, and may not receive income from any employment requiring services totaling more than twenty hours per week.

Special student. A student who does not wish or may not qualify for admission to the Graduate School as a graduate student may apply for admission as a special student. The person must hold a baccalaureate degree or have equivalent experience. He or she may register only for courses up to and including the 300 level at the standard tuition rate.

Admission depends on approval by both the relevant major department and the Graduate School office. Satisfactory

performance as a special student may qualify the student to apply for admission to the Graduate School but no courses taken as a special student may be submitted for credit toward a graduate degree.

Graduate Registration

Several days are set aside for graduate registration just prior to the beginning of the semester. However, a student, once admitted, can complete advance registration by obtaining a registration ticket from the department and arranging in advance for an interview with the adviser.

Anyone who can register in advance is urged to do so. Normally students are expected to complete their registration before the first day of instruction. A late fee of $20 is charged for registration after the start of instruction. Registration after the tenth day of instruction in a regular semester or the fifth day in a summer session is permitted only when the express consent of the dean of the Graduate School has been obtained. Unregistered students are not permitted to attend classes beyond the ten-day grace period.

It should be noted that graduate work itself starts promptly at the beginning of the term, and it is frequently true that graduate courses can be given only if there is a certain minimum demand for them. Delay in enrolling for a given course may therefore cause the course to be withdrawn.

Tuition and Fees

The tuition in the Graduate School is $2,065 per semester or $175 per semester hour for 1978-79. For 1979-80, tuition will be $4,550 ($2,275 per semester), or $190 per credit hour. A listener's fee is charged for each course audited, unless the student is already paying the full tuition fee. The maximum full-time roster of graduate courses, including audited courses, is fifteen semester hours. No exception to this rule is made. All students using the resources of the university must be registered, including the semester in which they receive a degree. The minimum registration fee is $150.

In addition to the usual tuition, an intern student is required to pay a $450 per year intern fee.

Bills are paid at the bursar's office, Alumni Memorial Building. If desired, payment may be made in installments: sixty percent plus a service charge of $3 per semester, due prior to registration; twenty percent due one month after registration; twenty percent due two months after registration. The service charge is not refundable.

The university will award educational grants to full-time elementary and secondary school personnel enrolled in the Graduate School. These grants are for teachers who are engaged in full-time service or on leave from such appointment. The grants will amount to $90 per semester hour in 1979-80; the student pays the balance of $100.

To qualify for the doctorate, all students must pay tuition fees equivalent to three full years (ninety credit hours) beyond the bachelor's degree or two full years (sixty credit hours) beyond the master's degree. Until these fees are met, resident doctoral candidates must pay a minimum registration fee for nine credit hours each semester and summer period. Similarly, part-time doctoral candidates must register for a minimum of three credit hours of courses or dissertation until the fees are met.

Thereafter doctoral candidacy must be maintained by a registration fee of $150 per semester and summer period until work for the degree is completed. However, resident students who, during their entire doctoral program, have paid continuously full tuition (or ten hours per semester in the case of teaching assistants and research assistants) will be considered as having satisfied the tuition requirements for the doctoral degree if they complete all other degree requirements while so registered.

Doctoral candidates registering for dissertation should indicate credit hours corresponding to the tuition paid. This procedure will assure that proper credit toward the minimum tuition fees is recorded. When the sum of the program course credits and dissertation credits rostered beyond the master's degree (or its equivalent of thirty semester hours) reaches a total of sixty semester hours, the minimum tuition fees will have been met. The dean of the Graduate School should be consulted in any case where the proper registration is in doubt.

The fee for each language examination required of the student by the department is $10.

The fee for microfilming and binding of the master's thesis is $20, the receipt for which is presented with the completed thesis to the Graduate School office.

In the case of the doctorate, the publication fee is $40. If a copyright of the dissertation is desired, an additional fee of $20 is required.

Identification cards, entitling the holder to attend the various campus events, are issued without charge to graduate students registered for nine credit hours or more.

Transcripts

Each student is entitled to one copy of the record free of charge. This can be an official or unofficial transcript. Unofficial copies are released to the student; official copies are sent directly to the educational institution, company, state board, etc., as the circumstances may require. After the first copy is released, a fee of $1 is assessed for each copy.

Refunds

A graduate student who formally withdraws from the university or who, on the advice of the department chairman and with the approval of the dean, finds it necessary to reduce the roster below twelve hours in any regular semester, may qualify for a tuition refund.

The amount of refund is equal to the tuition paid for the course or courses being dropped, less $50 for *each* three-credit course if the course is dropped in the first ten days of instruction. After the tenth day, the penalty is three percent of the tuition per day, counted from the first day of instruction. There is no refund for semester hours dropped if the remaining roster totals twelve or more hours.

A summer session student who formally withdraws from the university is entitled to receive a refund of the total tuition less $5 for each credit hour for which the student is registered and less a deduction for each day of regular instruction of four percent of the total tuition paid computed from the first day of instruction in the session.

In the event of the death of a student or involuntary induction into the armed forces, fees will be refunded in proportion to the fraction of the semester remaining at the time of death or induction.

A student who is suspended or expelled is not entitled to any refunds.

Degree Information

The maximum roster of a full-time graduate student is fifteen semester hours. Graduate students who are employed elsewhere and can give only part of their time to graduate work must restrict the size of their rosters accordingly.

Graduate students who hold university appointments of any kind are permitted to enroll for only a limited amount of graduate work. Full-time employees of the university may not take more than six semester hours of graduate work in any one semester; half-time employees may not take more than ten semester hours.

With the consent of the chairman of the major department and the chairman of the department concerned, a graduate student may be admitted as a regular listener in one or more courses, which course(s) shall be outside the approved program of studies for the degree, provided that the total number of hours in which he or she is registered and in which the person is a listener shall not exceed the limits set forth above. In no case shall a student who has attended a course as a listener be given an examination for credit in that course. A listener's fee is charged for each course audited.

Students desiring to qualify for graduate degrees in the minimum time should have pursued an undergraduate major in the subject equivalent to that offered at Lehigh. At the discretion of the chairman of the department, a limited number of credits in closely allied subjects may be accepted in lieu of courses in the undergraduate major. Those with undergraduate deficiencies who are admitted because they are otherwise well qualified will be expected to make up such deficiencies in addition to satisfying the minimum requirement for the degree sought.

Filing of Application for Degree

Candidates for degrees to be conferred on University Day in May or June file with the registrar, on a form provided for the purpose, on or before March 1, a written notice of their candidacy. Candidates for degrees to be conferred at Founder's Day in October file a similar notice on or before September 1. Candidates for degrees conferred in December must file on or before November 15.

Failure to file such notice by the dates mentioned may bar the candidate from receiving the degree at the ensuing graduation exercises. If a late application can be accepted, the candidate is assessed a $20 fee to help cover the extra cost of processing.

In addition to the degree requirements set forth below, there may be departmental requirements in the field of the major. These requirements appear in Section V.

Master's Degree Requirements

The master's degree is granted to properly qualified students who complete satisfactorily at least two full semesters of advanced work. In meeting the requirements for a degree, the student must comply with the following regulations.

Each candidate for the master's degree must submit for the approval of the graduate committee the program of courses he or she proposes to take to satisfy the requirements. This program must have the approval of the chairman of the student's major department, and all courses included which are not offered by the student's major department must also be approved by the chairmen of the departments concerned. The program should be submitted as soon as possible after completion of fifteen credits toward the degree. Approval of the program by the graduate committee signifies that the student has formally been admitted to candidacy for the degree.

The minimum program for the master's degree includes:

Not less than thirty semester hours of graduate work;
Not less than eighteen hours of 400-level course work;
Not less than eighteen hours in the major field;
Not less than fifteen hours of 400-level courses in the major field.

The eighteen hours required in the major field are ordinarily taken in one department. Specific exceptions to this rule are mentioned in the departmental statements in Section V. The remaining twelve hours of a minimum program, or any part of them, may also be taken in the major department; or they may be taken in any other field in which courses for graduate credit are offered, as the needs or interests of the student may indicate, subject to the approval of the chairman of the major department. In all cases, the work for the master's degree must be taken under at least two instructors.

Graduate students registered in 200- and 300-series courses may be assigned additional work at the discretion of the instructor.

In order to qualify for the master's degree, candidates are required to submit a thesis or a report based on a research course of at least three credit hours, or to pass a comprehensive examination given by the major department. The department will specify which of these requirements applies, and may specify both. If required, the thesis shall not count for more than six semester hours. The credit to be allowed shall be fixed by the chairman of the major department.

One unbound typewritten copy of the thesis, approved by the faculty members under whom the work was done and by the chairman of the major department, shall be placed in the hands of the dean of the Graduate School with a receipt for $15 to cover the fee for microfilming at least three weeks before the day on which the degree is to be conferred. Information as to the form in which the thesis must be presented may be obtained from the office of the Graduate School.

The master's degree is not granted unless the candidate has earned the grades A or B in at least eighteen hours of academic work. No course in which the grade earned is less than C is credited toward the degree. A student who receives more than four grades below B in courses numbered 200 or higher becomes ineligible to qualify for the master's degree or to register for any other 400 courses.

All work which is to be credited toward a master's degree must normally be done in attendance at Lehigh University, and must be completed within a six-year period.

When all requirements have been met, the candidate is recommended by the faculty to the trustees for the master's degree appropriate to the work pursued.

Doctor of Philosophy

The degree of doctor of philosophy (Ph.D.) is conferred on candidates who have demonstrated general proficiency and high attainment in a special field of knowledge and capacity to carry on independent investigation in that field as evidenced by the presentation of an acceptable dissertation embodying the results of original research. The requirements are more specifically set forth in the following regulations.

Candidacy

Time requirements. A candidate ordinarily is expected to devote three or more academic years to graduate study. In no case is the degree awarded to one who has spent less than two full academic years in graduate work. Study for any specified

period of time, however, is not in itself regarded as sufficient ground for awarding of the degree.

Graduate work done in residence at other institutions will be accepted in partial fulfillment of the time requirements, provided such work is approved by the graduate committee and by the departments concerned.

Work of fragmentary character scattered over a long period of years, or work completed many years before the student becomes a candidate for the degree, is subject to special review by the graduate committee. The extent to which such work may be credited towards the fulfillment of the time requirements will be decided by the committee. All postbaccalaureate work submitted in a program for the Ph.D. degree must be completed within a ten-year period. Candidates entering the doctoral program with a master's degree after a lapse of several years must complete work within a five-year period.

Residence requirements. A candidate for the degree must complete at least one full academic year of resident graduate study at Lehigh University. The candidate is required to maintain continuous registration until he or she completes all requirements for the degree, including the semester in which the degree is granted.

Approval of the doctoral program. Candidates for the doctorate are accepted in a limited number of departments only, and a department may limit the number of candidates accepted in any year. In passing upon a student's program, the committee takes into consideration the applicant's general education, as well as his or her special qualifications for work in the chosen field. Each applicant is notified by the dean of the Graduate School, in writing, of the action of the committee upon the application.

The student and faculty adviser are expected to initiate steps for approval of the student's program in the first semester following completion of thirty hours of graduate credit. The department determines by examinations or other credentials whether the student is qualified. Application should be submitted to the graduate committee not later than one year after completion of the master's degree or its equivalent. Information on the procedure to be followed can be obtained in the Graduate School office.

The application of a foreign student must be accompanied by a statement from the department in which he or she intends to specialize, certifying that the student has a satisfactory command of English.

A special committee is formed to guide the student in the doctoral program. The student should consult with the adviser on the naming of the committee and the preparation of the application as early as possible after passing qualifying examinations or having been accepted by the department to pursue the degree. The committee is charged with the responsibilities of assisting the student and the adviser in formulating a course of study and preparing a suitable proposal for the dissertation, of overseeing the progress of the student in research, and of assessing the final dissertation. Four members are appointed, at least one of them from outside the department. The membership of the committee is approved by the graduate committee.

Plan of work. Preparation for the degree is based on the study of a major subject to which one or two minors may be added.

The program of work, to be formulated by the candidate, the special committee, and the chairman of the major department, should be planned to lead to a general mastery of the major field and to a significant grasp of any minor that may be added.

While there is no definite requirement as to the number of courses to be taken, two years devoted to formal courses is customary.

Language requirements. Language requirements for the doctor of philosophy degree are the option of, and in the jurisdiction of, the candidate's major department. They are not a university requirement for the degree. Each major department decides which languages, if any, shall form a part of each candidate's doctoral program.

Language examinations are the responsibility of a committee consisting of representatives of the language department concerned and of the candidate's major department. Fee for each examination is $10.

Permission to take the language examination does not imply admission to candidacy for the degree.

Examination and Dissertation

General examinations. The general examinations for the doctorate are designed to test both the student's capacity and proficiency in the field of study. The examinations are not necessarily confined to the content of courses that have been taken at Lehigh University or elsewhere. They are held not later than seven months prior to the time when the candidate plans to receive the degree. The student's special committee is in charge of the examinations, which may be written and oral.

Should a candidate fail in any part of the general examinations, he or she may be permitted by the graduate committee to undertake a second examination not earlier than five months after the first. If the results of the second trial also are unsatisfactory, no further examination is set.

Dissertation. The candidate is required to present a dissertation prepared under the general director of a professor at Lehigh University.

The dissertation shall treat a topic related to the candidate's major subject, embody the results of original research, give evidence of high scholarship, and constitute a contribution of knowledge. It must be approved by the professor under whose direction it was written, by the candidate's special committee, and by the graduate committee.

A copy bearing written approval of the professor in charge must be presented to the dean of the Graduate School for transmission to the student's special committee not later than April 15 if the degree is to be conferred in May or June; not later than September 1 if the degree is to be conferred in October; and not later than November 9 if the degree is to be conferred in December.

In order that the student receive proper credit for tuition payments toward the minimum required, registration for dissertation should indicate the semester hours covered by the payment.

The candidate shall deposit the following with the dean of the Graduate School, at least two weeks before the degree is to be conferred: the original or perfect black and white typescript of the accepted dissertation, unbound, in standard form, and suitable for microfilming; the first carbon copy of the accepted dissertation; two copies of an abstract of the dissertation, not exceeding six-hundred words, accompanied by a letter from the dissertation supervisor stating that the abstract is acceptable and suitable for publication; a receipt from the bursar for the payment of the publication fee of $40.

The publication fee is used by the university to defray the cost of publishing the dissertation on microfilm (through University Microfilms) and the abstract in *Dissertation Abstracts*. If the candidate wishes to copyright the dissertation, he or she may do so by paying the copyright fee of $20 to the bursar at the time the publication fee is paid. Arrangements for the copyright in the author's name will then be made by the university through University Microfilming.

Final examinations. After the rough draft of the dissertation has been returned from the Graduate School, the student should distribute copies to members of the special committee.

The student will arrange a suitable date for the defense of the dissertation, allowing time for the special committee to examine the draft. The date is sent to the Graduate School office for information.

The examination is open to the public, and the department may enlarge the membership of the official examining committee as it sees fit.

Doctor of Arts

The degree of doctor of arts (D.A.) is offered in the fields of business and economics, chemistry, government, and psychology for students who desire to prepare for a career in college teaching in one of those fields.

In every respect, admission standards are equal to those for the doctor of philosophy programs, and the doctor of arts programs have been developed in accordance with guidelines issued by the Council of Graduate Schools.

The requirements for the doctor of arts degree parallel those for the doctor of philosophy with the following exceptions: a broader distribution of graduate courses in the field; a minor area of study for those students wishing bidisciplinary preparation for two-year college teaching; course work and training in interpersonal awareness; a supervised internship in college teaching, and a project appropriate to college teaching in the field instead of a research dissertation.

Doctor of Education

The degree of doctor of education (Ed.D.) is intended for a limited number of carefully selected students engaged in the fields of administration, counseling, foundations, reading, measurement and research, and teaching. Successful professional experience is required for admission to candidacy for this degree.

In general, requirements for the doctor of education degree parallel those already stated for the doctor of philosophy degree with the exception of the following: language examinations are not required; a statistics competency examination is required; and a residence requirement may be satisfied by an academic year of full-time study or a semester of full-time study preceded or followed by a summer session in which twelve semester hours of credit are earned.

There is enough flexibility in this program to permit certain modifications appropriate to the specific objectives and background of the doctoral student. For more detailed information, consult the dean of the School of Education, and see the pages which follow on the School of Education.

Postdoctoral Work

Students who have completed the requirements for the doctorate may enroll for postdoctoral individualized study under the guidance of selected members of the faculty. Such a program of study contemplates a broad educational and research development at advanced and mature levels, and provides opportunities to prepare for specific positions. A formal certification of such work as may be accomplished by the student will be made.

Financial Help for Graduate Students

Financial support is available to graduate students from a number of sources and in various forms—scholarships, fellowships, traineeships, teaching and research appointments.The university recognizes that many students require help to meet the cost of graduate study, and encourages qualified students to explore all sources of financial aid.

Scholarships. A scholarship is a grant which covers or helps to defray tuition. Each is awarded on the basis of academic promise and financial need. No services are expected.

Fellowships and traineeships. A fellowship or traineeship is a grant to a graduate student which covers tuition and provides an additional stipend to help meet living expenses.

The university receives funds from individual donors and corporations which provide for the support of several graduate students on scholarships, fellowships and traineeships. In addition, government agencies and foundations offer fellowships and other grants which they award either directly to outstanding students for use at institutions of their choice or to institutions for award by them to the student.

Appointment to these fellowships is for a period of two semesters and may be renewed, provided the work of the holder is of such quality as to justify continuation of financial aid. Students who undertake research work should be able to use it for thesis or dissertation.

Annual stipends for most fellowships are $2,400 to $4,800, depending upon the qualifications of the applicant. Graduate fellows pay the regular tuition fees. However, the Graduate School, in awarding a fellowship, may award at the same time a graduate tuition grant. This grant provides remission of all tuition fees during the period it covers.

Teaching and graduate assistantships. Many graduate students hold junior academic staff positions as teaching or graduate assistants. They assist the faculty in grading undergraduate quizzes, instructing in the classroom and laboratory, and conducting recitations.

The department view seriously the benefits of a teaching or graduate assistantship as a preparation for a career in college or university teaching.

A number of teaching assistantships are available in applied mechanics, biology, business administration, chemistry, English, education, geological sciences, government, history, international relations, mathematics, physics, psychology, and in chemical, civil, electrical, industrial, mechanical, and metallurgical engineering.

Half-time assistants devote fifteen to twenty hours per week to their duties and receive $3,800 to $4,000 for the 1979-80 academic year. In addition, to qualify for the appointment, the assistant also merits award of a scholarship for tuition. Assistants may take up to ten hours of graduate work a semester.

Appointments to assistantships are made upon recommendation of the department chairman. Therefore, a student who wants such a position should write to the department chairman. However, forms for admission to the Graduate School are filed with the office of admission.

Research assistantships. The university cooperates with industrial concerns, technical associations and governmental agencies in carrying on basic and applied research. A number of research assistantships are available to qualified graduate students who assist with these research programs.

Many students value the opportunity to participate with senior faculty members in an ongoing project. The experience enlivens their course work and often determines

the topic of the thesis. Research assistants are appointed to a project to do research that also meets the research requirements of the degree program in which the student is enrolled. Appointment to a research project as an assistant whose duties do not meet degree requirements is designated project assistantship.

Applications for research assistantships should be accompanied by evidence of the candidate's qualifications for the appointment sought and sent to the director of the Lehigh Office of Research or to the chairman of the department concerned.

Research and project assistants received stipends up to $800 per month for 1979-80, depending upon the qualifications and academic program of the appointee and the time assigned to the project. Appointments are generally for one year and normally are continued upon satisfactory academic progress. Part- or full-time employment on research projects is frequently available during the summer and entering students who hold research appointments usually are encouraged to begin their employment in June or July before the commencement of formal graduate study in the fall.

Research and project assistants holding appointments for half-time or more pay the set tuition until they have met the tuition requirements of the degree for which they are candidates.

Applications for Aid. A graduate student may apply for any of the scholarships, fellowships or traineeships awarded or administered by the university, including those granted by national agencies for presentation by the university, by completing the application form available from the office of admission.

Each applicant is automatically considered for all awards for which he or she is eligible. Application must be completed on or before February 1. Each form must be supplemented by an official transcript of the candidate's college work, a statement concerning his or her practical experience, and any other evidence of qualifications which the student may choose to submit.

Scores made by the applicant in the Graduate Record Examination; or, for those in education, the National Teachers Examination; and for master of business administration candidates, the Graduate Management Admission Test are generally required.

Final action on applications is taken on the recommendations of departments to the Graduate School. Notices of award are mailed in March. In accordance with a resolution of the Council of Graduate Schools in the United States, to which more than 180 graduate schools have signified their assent, a student has until April 15 to decline an award.

The holder of a scholarship, fellowship or traineeship may not accept any employment for pay without permission of the dean of the Graduate School.

Student Loan Funds

The university administers a loan fund program under which financial assistance, both long-term and short-term, is available to graduate students.

A student may borrow when there is no other support from the university, or to add to income from a fellowship or assistantship. To be considered, a student must provide complete details of the personal budget.

Information concerning application for a loan may be obtained from the office of financial aid. Available loan funds include:

National Direct Student Loan Program (NDSLP). As federal funds are available to the university, the direct loan program makes it possible to borrow for graduate study to a combined graduate/undergraduate total of $10,000 per person. The office of financial aid determines which students are eligible and the amount of the loan. Repayment begins nine months after the student ceases at least half-time study, and may extend over a ten-year period. Interest charges of three percent also begin at the start of the repayment period. Eligibility is limited to U.S. citizens or permanent residents who are enrolled on no less than a half-time basis.

University Tuition Loan Program (UTLP). Loans are made available on the basis of need to graduate students carrying at least a half-time academic load. Interest charges of four percent annually begin from the date of the note. Repayment begins ninety days after the student ceases at least half-time study, at a minimum rate of $50 monthly.

Guaranty Student Loan Program (GSLP). The program is a long-term interest-subsidized, deferred repayment loan program. The student borrows directly from a bank, credit union, or savings and loan association. Graduate students who are U.S. citizens or immigrants holding a permanent resident visa (I-151) or refugees paroled by the U.S. attorney general are eligible if they are enrolled on at least a half-time basis (in credit hours per semester). Graduate students may borrow up to $5,000 per academic year to a maximum of $15,000 including all undergraduate loans. Such loans must be repaid in full—including interest unless the borrower dies or is totally disabled. Repayment begins nine months after termination of enrollment for at least six credit hours per semester.

U.S. Steel Loans. Loans are available to U.S. citizens studying in engineering, physical sciences or business. Loans up to $2,500 per year ($5,000 limit) are awarded on the basis of need and merit. They are interest-free during residency and at the rate of two percent during repayment. Repayment will be at $1,000 per annum or 25 percent of the loan, whichever is less. Applications are available from the office of the dean of the Graduate School.

Business and Economics Programs

The Graduate School, in association with the College of Business and Economics, offers three degrees at the master's level: the master of business administration, the master of arts, the master of science. On a more advanced level, the college offers the doctor of philosophy and the doctor of arts degree.

Graduate education in the College of Business and Economics distinguishes by emphasis between professional management training through the M.B.A., which generally though not always concludes as the master's level, and graduate pursuit of business and economics subjects in depth for research and/or teaching expertise through the doctoral and related M.A. and M.S. programs.

A candidate for admission to graduate study in the College of Business and Economics offers either the Graduate Management Admission Test (GMAT) for business degrees or the Graduate Record Examination (GRE) Aptitude Tests and the advanced test in economics.

Master of Business Administration

The master of business administration degree is designed to give candidates conceptual, analytical, and operational knowledge of decision-making processes in the management of human and physical resources.

Both internal and external aspects of enterprise and organization in modern economic systems impinge upon managerial roles. Education in the business professions requires understanding business functions and integrating them into the management process. The program requires

generalized managerial competence but permits, if the student desires, advanced concentration in such fields as finance, marketing, quantitative or behavioral management, professional accountancy or economics, international trade and finance, labor relations, and so forth.

All candidates for this program are required to take the Graduate Management Admission Test (GMAT) for business degrees. Information about this test may be obtained at many counseling centers or by writing to the Educational Testing Service, Box 966, Princeton, N.J. 08541.

The courses listed below are available in the evening or on Saturday morning to permit qualified candidates to obtain the degree on a part-time basis. Ordinarily graduates of a four-year program in business and economics complete the M.B.A. in one year on a full-time baiss. Normally, two years as a full-time student is required to complete the M.B.A. degree for those candidates who have not previously completed any of the foundation courses listed below.

Foundation Courses (30 credit hours)

Quantitative Methods and Systems

Acctg 415	Financial Flows & Accounting Measurements (3)
Acctg 411	Computers and Management (3)
Eco 417	Basic Statistics for Business (3)
Mgt 441	Quantitative Methods in Business and Economics (3)

Functional and Organization Studies

Fin 401	Managerial Finance (3)
Mket 407	Marketing Strategy (3)
Mgt 413	Organizational Behavior (3)

Economic and Legal Environment

Eco 429	Money, Banking and Monetary Policy (3)
Eco 405	Microeconomic Theory (3)
Law 403	Commercial Transactions and Business Organizations (3)

Students are usually given credit without examination for one of the foregoing courses with grades of C or better if taken toward a prior degree earned not more than eight years before matriculation in the M.B.A. program. Comparable undergraduate courses at Lehigh which will satisfy the foundation course requirements are: Eco 45, 105, 229; Acctg 51, 111; Fin 225; Law 201; Mkt 211; Mgt 302 and Mgt 270.

Required Core Courses (18 credit hours)

The following courses are taken at the end of the program.

Eco 431	Managerial Economics (3) *or*
Eco 432	Advanced Microeconomic Analysis (3)
Mgt 402	Operations Management (3)
Mgt 451	Managerial Policy and Decision Making (3)

One 400-numbered course (beyond foundation courses) is taken in three of the following four functional areas: Accounting (3), Finance (3), Management (3), Marketing (3). Those students who have not taken a managerial accounting course (or equivalent) must take Acctg 422 as one of the three courses.

Foundation courses should be completed before second-year courses are taken. At least six of the second-year courses must be 400-number courses.

Elective Courses (12 hours)

Elective credit hours may be selected from desired combinations of 300- and 400-level courses offered in the College of Business and Economics, as described under the various departmental listings. Up to six credits can be taken in other colleges with the consent of the M.B.A. adviser.

Of the total of sixty credits, the last thirty credits are taken at Lehigh University and must meet the university graduation requirements for any master's degree.

Ph.D. in Business and Economics

The intention of the doctor of philosophy program is to nurture intellectual growth so that the student may independently pursue personal or professional goals. It is assumed that the individual's level of proficiency attained at the completion of the degree program will continue to increase with professional development.

Each student is expected to pursue an intellectual and scholarly interest in four areas of study, including economic theory. This program of study is designed to prepare the student to pass comprehensive examinations in each of the four areas. In addition, a research core of twelve hours of course work in statistics, research methodology, and mathematical models is required.

Having satisfactorily completed the comprehensive examinations, the student is expected to undertake research culminating in a formal dissertation. The dissertation should treat a topic related to the candidate's principal field of specialization, embody the results of original research, and constitute a contribution to knowledge.

Doctor of Arts in Business and Economics

The philosophy of the doctor of arts program is to provide advanced graduate work along with sensitivity and teaching skills in preparing individuals for teaching careers at two-year and four-year colleges.

As in the Ph.D. program, the student is expected to pursue four areas of study (including economic theory) in preparation for comprehensive examinations. In addition, a core of twelve hours of courses focusing on problems of teaching, learning, sensitivity, and interpersonal relations must be taken.

Further requirements include a teaching internship and a dissertation dealing with teaching, learning, or research problems in business or economics.

M.A. and M.S. in Business and Economics

The master of arts degree is offered to students interested in pursuing graduate work in economics or in economics and business. A minimum of thirty semester hours of course work is required. At least eighteen of these hours must be taken within the College of Business and Economics.

In addition, the student will be expected to pass comprehensive examinations in general economic theory and one other field in the college.

To qualify for the master of science degree, the student must also take Eco 352, Advanced Statistical Methods, and Mgt 441, Quantitative Methods, in addition to the other requirements described above.

The college participates in the master of science in management science program. See page 66 for information.

School of Education

Perry A. Zirkel, *dean*

The School of Education was established in 1966, elevating it from its former departmental status under the College of Arts and Science. The School of Education operates in conjunction with the Graduate School in regard to admission, registration, tuition, fees, transcripts, and other related matters.

Degree requirements are also consistent with those

established by the Graduate School. The School of Education offers the master of arts in education, the master of education, the master of science in education and the doctor of education. Details regarding the specific regulations and requirements can be found in the section on the Graduate School. Course offerings and other pertinent data may be found in Section V.

For the benefit of those employed full-time, most courses are offered in the late afternoon, evening or on Saturday morning. A full summer school program is scheduled as well. Teachers in the Lehigh Valley and surrounding regions are encouraged to participate in the life and work of the university.

The school is engaged in the preparation of elementary and secondary teachers in both school and nonschool settings; school and community counselors; school psychologists; school and college administrators; reading specialists; curriculum specialists; specialists in the foundations of education; specialists in the education of mentally and emotionally disturbed children; teachers of preschool children, especially those children with handicaps; teachers for the social restoration of potential delinquents; and specialists in measurements and research.

The school is interested in potential and established leaders in all aspects of educational endeavor. More than 800 students were involved in advanced study at the master's and doctoral levels in the 1978-79 academic year.

Through its working relationship with other colleges and universities in eastern Pennsylvania, Lehigh has undertaken to complement existing undergraduate preparation programs by emphasizing study at the graduate level. Off-campus course work and in-service projects are an integral part of many programs.

An intern teaching program is specifically designed for qualified persons holding bachelor of arts degrees who desire to enter the field of teaching. Those admitted to this program have the opportunity to accomplish their professional training and serve as salaried interns in the public schools. After two semesters of directed full-time study, students may begin the teaching internship. Upon completion of the fifth-year program and the required semesters of intern teaching, such students would ordinarily have completed requirements for the master of arts degree (secondary teachers) or the master of education degree (elementary teachers), as well as state certification.

Program of Study

Lehigh's program of training for advanced professional responsibility is planned in three stages. The first is represented in the master of education, master of arts, or master of science degree programs; the second exists in the several specialist certification programs; and the final stage is the doctor of education program.

Master of Education (M.Ed.). This degree requires, in addition to study of the foundations of education, specialization in a professional field. Special fields include elementary education, administration, social restoration, elementary school counseling, secondary school counseling, community counseling, guidance supervisor, school pscyhology, special education, career education, reading specialist, and reading supervisor.

Master of arts (M.A.). This degree program provides a major in education with an academic specialty. Candidates for this degree must include in their program a minimum of twelve hours of graduate work in an academic field. The balance of the program is in the foundations of education and instructional process.

The academic fields which now cooperate with the School of Education in offering this degree include: classical languages, mathematics, English, modern foreign languages, economics, government, social relations, history, international relations, and physical and natural sciences.

Master of Science (M.S.). This degree in educational measurements and research is designed to prepare graduates for an increasing number of challenging positions involving research, testing and evaluation in school districts, state departments of education, or other educational institutions.

Although study at the master's level is specialized, the school recognizes that additional training is needed for professional leadership in most areas. Therefore, programs designed for these specialists are extended to the post-master's level. Certification requirements extend beyond the master's degree.

Doctor of Education (Ed.D.). This program provides for major work in seven areas: administration, counseling, elementary education, foundations of education, measurements and research, reading, and special education.

Students are screened for admission in the fall and spring of each year and begin doctoral study the following semester. Formal admission to the doctor of education program usually occurs after the completion of fifteen hours beyond the master's level, although it may occur before the master's degree is earned.

Tuition Assistance

All students enrolled in the School of Education are entitled to an educational grant from the university of $90 per semester hour for 1979-80. The student pays the balance, which amounts to $100 per credit hour for 1979-80.

Organization

The School of Education is organized into three departments. These departments, their chairpersons, and the programs of study included within each are listed below.

Department of Administration and Supervision. LeRoy J. Tuscher, chairperson. Elementary school principal, secondary school principal, school business manager, curriculum administration, school superintendent, college administration.

Department of Human Development. Paul VanR. Miller, chairperson. Elementary school counselor, secondary school counselor, community counselor, supervisor of guidance services, social restoration specialist, reading specialist, reading supervisor, school psychologist, measurements and research specialist.

Department of Instruction and Curriculum. Robert L. Leight, chairperson. Elementary teachers, secondary teachers, preschool teachers, special education teachers, career education teachers, educational foundations.

Consult Section V, Education, for courses offered by these departments.

Centennial School. The School of Education also operates the Centennial School—a laboratory facility for exceptional children which has both an elementary and secondary component. The Centennial School provides research opportunities as well as practical experience for advanced

students in counseling, school psychology, special education and reading.

The laboratory facility is housed in a separate, modern building in the Saucon Valley complex.

The staff of the school is listed in Section VI.

Undergraduate Minor in Education. Upper-level undergraduates are given an opportunity to take a minor in Education which combines practicum activities with theoretical work, designed to provide a foundation for further educational studies at the graduate level. A description of the program is found on page 38.

Postdoctoral Work

Students who have completed the requirements for the doctorate may enroll for postdoctoral individualized study under the guidance of selected members of the faculty. Such a program of study contemplates a broad educational and research development at advanced and mature levels, and provides opportunities to prepare for specific positions. A formal certification of such work as may be accomplished by the student will be made.

General Information

Campus events. The cultural and athletic events of the university are open to graduate students who request identification cards, and recreational facilities are for the use of all. Lehigh Univeristy provides a wide range of social and athletic activities, concerts and dramatic productions, and art and book exhibits for students and their guests, for faculty, neighbors and alumni.

Housing. Many resident graduate students live in rooms or apartments near the campus, although from time to time a limited number of living accommodations are available in the undergraduate residence halls on the campus. The university's Saucon Married and Graduate Students development, which opened in 1973, provides efficiency, one-bedroom, two-bedroom, and three-bedroom garden-style apartments in a rural setting on the periphery of the Saucon Valley athletic campus. Undergraduates also are housed in this facility.

Inquiries in regard to accommodations for graduate students, either married or single, can be directed to the Residence Operations Office, Rathbone Hall #63, Lehigh University, Bethlehem, Pa. 18015. The university cannot assume responsibility for locating housing. Since accommodations can be scarce, the student is advised to arrange for housing well in advanced of beginning residence.

Child care facility. A child care facility is available on a limited basis to Lehigh students, staff and faculty. Children between the ages of six weeks and five years can be enrolled on a first-come, first-serve basis. Fees are charged on a weekly basis, and limited scholarship aid may be available to those in financial need.

The facility, known as the Campus Center, operates five days per week from 7:30 A.M. until 5:30 P.M., year-round. The center, which is near the campus, is a joint effort of the Lehigh University Committee on Child Care and Lehigh Valley Child Care, Inc.

Those desiring information should contact the Community Relations Office, Johnson Hall #36, Bethlehem, Pennsylvania 18015.

Parking regulations. Graduate students are expected to comply with campus parking regulations. They register their automobiles at the motor vehicle office, located in Johnson Hall. No fee is charged for registration.

Accident and sickness reimbursement insurance. The university requires all resident graduate students to carry the accident and sickness insurance coverage which is available at nominal cost at the bursar's office, unless the student can present evidence of other approved coverage.

All students are required to carry insurance for both accident and illness either through the university or by other approved policies.

Evening classes. For the benefit of graduate students who by reason of employment in the fields of teaching or industry cannot attend classes during the day, a certain number of courses are generally offered in the late afternoon, evening, and on Saturday morning. It cannot be announced in advance which courses these will be, but a student who is interested may receive the necessary information by communicating, before the beginning of each semester, with the chairman of the department in the field of interest.

In recent years evening and Saturday classes were held in accounting, business law, chemical engineering, civil engineering, economics, English, finance, government, history, industrial engineering, marketing, mathematics, mechanical engineering, metallurgy, and psychology. It is anticipated that in the future courses will be offered as the demand warrants.

Summer session. During the summer, the university offers a comprehensive program for undergraduates and graduate students of two sessions of six weeks each.

Many workshops and special programs dealing with pertinent topics such as special engineering courses in surveying, reading and study developmental laboratory programs, overseas programs, and a variety of other special credit and noncredit workshops and conferences are offered.

The special-interest programs are designed around the interest of the student population which normally is in attendance at Lehigh.

Interdisciplinary Study in Graduate Programs

Computer Science

An interdisciplinary program is offered in computer science leading to the degree of master of science. It is supported by departments of the university with considerable resources in the field and an extensive list of course offerings. These departments and divisions also are active in research related to computer science, including the following:

1. In electrical engineering, research is under way in equipment organization, software engineering, coding theory, and devices for digital systems.
2. In information science, research is conducted in linguistics, information retrieval, and software systems.
3. In industrial engineering, research is concerned with operations research and management systems.
4. In mathematics, research includes automata theory and mechanical theory-proving.

The computer science program is available to students from many undergraduate disciplines. In some cases background courses may be required to provide necessary prerequisites. The student should have the following preparation:

1. Skill in programming in a high-level language, and familiarity with a machine or assembly language.
2. Two years of college-level mathematics.

While the intention is to keep the program as flexible as possible to meet individual interests and needs, the student is normally expected to include in the program the following core subjects: mathematical methods in computer science; non-numerical programming; switching theory, and data structures.

Elective courses may be chosen from one or more of these areas: software and automata theory; hardware and logic design; numerical analysis; linguistics; computability; and applications.

A master's thesis or a research course must be included in the program to qualify for the degree. The student is enrolled for administrative purposes in one of the following departments: electrical engineering, industrial engineering, information science, or mathematics. The program, however, is supervised by an interdisciplinary faculty committee headed by the dean of the Graduate School.

Applied Mathematics

The committee on applied mathematics administers programs leading to the degrees of master of science and doctor of philosophy. These programs are interdepartmental and stress the application of mathematics to the physical and social sciences. They provide a broad, rather than a specialized, training in these fields.

The programs also are designed for candidates who have a basic training, either at the bachelor of arts or master of science level, in a field other than applied mathematics. The committee encourages such applicants. The degrees are in applied mathematics with a minor in some specified field of the physical and social sciences.

A candidate for these programs must have a knowledge of basic undergraduate mathematics which includes linear algebra and differential equations (for example, Math 205). If not taken previously, courses in complex variable theory and partial differential equations, although not prerequisites for admission to these programs, must be added to the student's course requirements.

All students in the doctor of philosophy program are required to pass a qualifying examination before the end of their fifth semester (not including summer sessions). For the master of science degree, a thesis is required in addition to the course requirements. Master of science candidates can enter the doctor of philosophy program after completing all course requirements (exclusive of thesis). The date of the qualifying examination for a student entering the program with a master of science degree—not necessarily in applied mathematics—will be determined on admission.

Several types of programs which are available to the student are listed below. These programs are not the only possible ones. Others can be arranged with the consent of the committee.

Core Courses

Math 320, 322 (Phys 428 and 429 may be substituted)
ChE 464

Options

1. Engineering Sciences
required: Mech 411, 450
electives
Math 405
Mech 409, 421, 424,
ME 448, 458, 459
CE 459
EE 350, 409
Phys 369, 442
Geol 301
Biol 402

2. Econometrics
required: Eco 320 or 436, 351, 432

electives
Math 309, 334
Eco 453, 455, 456
IE 416, 418, 445, 439, 311

3. Applied Analysis
required
Math 309, 350
Mech 450, 411

electives
to be chosen from lists under 1 and 2.

Management Science

The industrial engineering department, in conjunction with the department of management, finance and marketing, offers an interdisciplinary degree in management science.

The management science program is directed toward integrating the scientific method with the functional aspects of organizations by investigating the application of quantitative methodology and systems analysis in the context of such functional areas as accounting, finance, marketing and production. This integration provides the student with a broader perspective toward managerial decision-making in private enterprise and public administration.

Undergraduates with a background in engineering, business, economics, mathematics or the physical sciences who want a professional career as a staff specialist in management science are appropriate candidates. In addition, those candidates who intend to seek line manager positions find the management science background advantageous in dealing with the complex problems of industrial, commercial, and public service organizations.

The candidate is assumed to have acquired basic competence in the areas of accounting, marketing, corporate finance, production, data processing, microeconomics, linear algebra, calculus, statistics, and introductory operations research.

Required Courses

IE 418	Simulation
Mgt 321, IE 334 or Mgt 412	Organizational Behavior and Structure
Eco 431	Business Policy
IE (Mgt) 430	Management Science Project
nine hours of quantitative methods	
six hours selected from a functional area	

The minimum program consists of thirty hours of approved course work.

Sample M.S. in Management Science Program

IE 418	Simulation
Mgt 321	Organization Behavior
IE (Mgt) 430	Management Science Program
Eco 431	Managerial Economics
IE 311	Decision Processes

IE 417	Mathematical Programming
Eco 455	Econometric Models
IE 325	Production Control
Fin 421	Financial Management
Fin 431	Advanced Investment Analysis and Portfolio Management

Molecular Biology

The molecular biology program committee, consisting of faculty from the departments of biology, chemistry and physics, administers an interdisciplinary program in molecular biology leading to the master of science and the doctor of philosophy degrees.

The core courses provide a basic background in cellular and molecular biology, biochemistry and biophysics. Present active research areas include studies of molecular analysis of microbial behavior, biomolecular radiation damage, mitochondrial nucleic acids, viral diseases of fish, proteolytic enzymes of marine bacteria, assembly of viruses, cardiac enzymology, mechanisms of phosphate ester hydrolysis, and membrane biophysics.

Students are admitted to the departments of physics, chemistry or biology who have appropriate undergraduate preparation in the respective subject, or have backgrounds in molecular biology, biochemistry, biophysics or microbiology.

Master's degree requirements. The requirements for the master of science degree include thirty credits of graduate course work, eighteen of which are at the 400 level, and successful completion of a research project under the supervision of a committee member. A written report of the research must be approved by the research adviser and will be kept on file by the program committee.

Required Courses for the M.S. in Molecular Biology

Chem 371	Elements of Biochemistry I (3)
Chem 372	Elements of Biochemistry II (3)
Phys 367	Introduction to Molecular Biophysics (3)
Phys 368	Molecular Biophysics (3)
	approved 400-level biology elective (3)
	approved 400-level electives (6)
Chem 479	Biochemical Techniques (3)
Phys 491, 492, or Biol 407, 408, or Chem 474, 475	Research (6)

Electives

Students normally select the 400-level biology elective from among the following, although others may be approved.

Biol 416	Immunology
Biol 420	Cellular Mechanisms
Biol 425	Biological Electron Microscopy
Biol 445	Nucleic Acids
Biol 447	Experimental Molecular Biology

Additional required 400-level electives and supplementary courses may be selected from the lists below and above.

Phys 451	Topics in Biophysics (1-3)
Chem 423	Bio-organic Chemistry (3)
Chem 445	Elements of Physical Chemistry (4)
Chem 476	Microbial Biochemistry (3)
Chem 477	Topics in Biochemistry (3)
Chem 480	Advanced Biochemical Preparations (1-3)
Biol 325	Advanced Genetics
Biol 353	Virology
Chem 358	Advanced Organic Chemistry
Chem 395	Colloid and Surface Chemistry

Doctoral Degree Requirements. Course requirements for the doctor of philosophy degree in molecular biology are determined on an individual basis by the student and the dissertation committee. This determination is subject to approval by the program committee.

Before completing the requirements for the master of science degree, a student who desires to pursue a doctor of philosophy degree takes a qualifying examination, which may be both oral and written, and is administered by the program committee. Upon successful completion of this examination (which may be taken no more than twice), the student, in consultation with the research adviser, selects a dissertation committee which consists of the research adviser, at least three members of the molecular biology program committee, and at least one faculty member who is not a member of the committee. The dissertation committee must be approved by the program committee and by the graduate committee of the university.

Sometime prior to seven months before finishing the doctor of philosophy dissertation, the student must pass a general examination administered by the dissertation committee. The material covered in this examination is not limited to material covered in courses or obtained through laboratory experience. The student may be tested on all and any areas of molecular biology.

Upon completion of a draft of the doctor of philosophy dissertation, the student takes the final examination, which is essentially a defense of the thesis.

Physiological Chemistry

The graduate program in physiological chemistry is interdisciplinary and leads to the master of science and the doctor of philosophy degrees. This curriculum prepares individuals who want to pursue careers in biomedical research, teaching, or administration, or in some aspect of public health.

Individuals may elect to specialize in one of the following areas: nuclear medicine, medicinal chemistry, chemical and experimental parasitology, invertebrate pathobiology, comparative immunology, and chemical physiology. The core course distribution and selection of electives may be altered to reflect the area of specialization.

Students are enrolled in the department of chemistry and are provided with research space in the laboratories of the university's Center for Health Sciences.

Core Courses in Physiological Chemistry

Students select at least six of the following core courses:

Chem 303	Nuclear and Radiochemistry (3)
Chem 336	Clinical Chemistry (3)
Chem 371	Elements of Biochemistry (3)
Chem 423	Bioorganic Chemistry (3)
Chem 424	Medicinal and Pharmaceutical Chemistry (3)
Chem 479	Biochemical Techniques (1-3)
Biol 333	Symbiosis (3)
Biol 416	Immunology (3) *or*
Biol 432	The Biology of Transplantation (3)
Phys 367	Introduction to Molecular Biophysics (3)
Educ 455	Statistics I (3)*

*A mastery of the application of statistical methods to research can be fulfilled by completing one of several statistics courses, i.e., Educ 455, IE 410, Psych 421, and Math 231.

Students, with the consent of their graduate committee members, may petition to substitute equivalent courses form some for some of the required ones. The substitution must be approved for the student's area of research concentration. In

addition, each student selects, with the guidance of the committee, sufficient courses from the following to satisfy the requirements of the Graduate School.

Chem 310	Instrumentation Principles I (3)
Chem 311	Instrumentation Principles II (3)
Chem 358	Advanced Organic Chemistry (3)
Chem 372	Advanced Biochemistry (3)
Chem 421	Chemistry Research (1-4)
Chem 423	Bioorganic Chemistry (3)
Chem 424	Medicinal and Pharmaceutical Chemistry (3)
Chem 441	Chemical Kinetics (3)
Chem 445	Elements of Physical Chemistry (4)
Chem 458	Topics in Organic Chemistry (3)
Chem 476	Microbial Biochemistry (3)
Chem 477	Topics in Biochemistry (chemical basis of parasitism, immunochemistry) (1-3)
Chem 480	Advanced Biochemical Preparations (1-3)
Chem 481	Chemistry Seminar (1-6)
Biol 303	Invertebrate Zoology (3)
Biol 320	Cell Physiology (3)
Biol 322	Animal Physiology (3)
Biol 353	Virology (3)
Biol 402	Comparative Animal Physiology (3)
Biol 405	Special Topics in Biology (microbiology) (3)
Biol 413	Cytochemistry (3)
Biol 421	Morphogenesis of the Lower Invertebrates (3)
Biol 425	Biological Electron Microscopy (3)
Hist 339	Human Ecology and Public Health in America (3)
Hist 340	History of American Medicine (3)
IR 472	Special Topics (international public health policies) (3)

Students admitted into this program may have majored in biology, chemistry, animal science, entomology, veterinary science, pharmacy, or some other areas of the life sciences.

All students in the doctor of philosophy program are required to satisfy one foreign language requirement and pass a qualifying examination. The completion of a research project is required of master of science students. A dissertation is required of doctor of philosophy students.

Interdisciplinary Study in Areas Of Research

Polymer Science and Engineering

Lehigh has a strong and diverse group of faculty with primary interests in polymer science and engineering. In order to provide better opportunities for courses and research in this interdisciplinary field, activities are coordinated through a polymer program committee, with representatives from the departments of chemistry, chemical engineering, and metallurgy and materials engineering, as well as from the Center for Surface and Coatings Research and the Materials Research Center. The committee reports to the chairman of the department of chemical engineering.

Qualified students with degrees in the above or related fields may pursue graduate studies within an appropriate department. The student's adviser may be in that department, in another department, or in a research center. In this case, the student receives a normal departmental degree, but will have emphasized polymer courses and research.

Students also may elect to pursue studies towards an interdepartmental degree in polymer science and engineering. The procedures for this case are summarized below.

M.S. in Polymer Science and Engineering

For the master of science degree, the student is expected to:

1. Obtain a total of thirty credits of graduate course work, eighteen at the 400-level and eighteen core credits.

2. Complete a research report to the satisfaction of the faculty adviser, and file it with the polymer program committee.

The usual core courses are:

Chem (ChE) 390	Synthesis and Characterization Lab (3)
ChE (Chem) 393	Physical Polymer Science (3)
Chem (ChE) 394	Organic Polymer Science (3)
ChE (Chem)	400-level polymer course (3)
	Research (6)

Because polymer science and engineering embrace many variations on the common theme of macromolecules, considerable flexibility in course selection should be maintained. If deficiencies exist with respect to other undergraduate courses, additional courses may be required; however, some requirements may be waived for a student who already has a background in polymer science or engineering.

In addition to the required core courses, at least nine elective credits are required at the 400 level. Typical appropriate courses are:

ChE (Chem) 482	Engineering Behavior of Polymers (3)
Chem (ChE) 483	Emulsion Polymers (3)
ChE (Chem, Met) 484	Crystalline Polymers (3)
ChE (Chem) 485	Polymer Blends and Composites (3)
Chem (ChE) 492	Selected Topics in Polymer Science (3)
Met 334	Electron Microscopy and Microprobe (3)
ChE 400	Thermodynamics (3)
ChE 413	Catalysis (3)
ChE 428	Rheology (3)
Chem 445	Elements of Physical Chemistry (4)
Chem 497	Topics in Surface Chemistry (3)

Other courses may include thermodynamics, mathematics, mechanics, statistics, kinetics, solid state, organic or biochemistry, etc.

Ph.D. in Polymer Science and Engineering

For the doctor of philosophy degree, the student must:

1. Satisfactorily complete a qualifying examination in a relevant scientific or engineering discipline administered by the appropriate department, or, in the case of a student with a background primarily in polymers, by the polymer program committee.

2. Satisfactorily complete graduate course work determined in consultation with the thesis committee and as approved by the polymer program committee.

3. Satisfactorily complete, prior to completion of the doctor of philosophy dissertation, a general examination (reflecting the polymer field at large) administered by the polymer program committee.

4. Complete and defend to the satisfaction of the thesis committee a doctor of philosophy dissertation and also a general knowledge of the field.

The thesis committee consists of the research adviser, at least two members of the program committee, and at least one faculty member who is not a member of the committee; the committee's composition is subject to approval by the polymer program committee and the graduate committee.

For further information, write to Professor John A.

Manson, Materials Research Center, Coxe Laboratory #32, Lehigh University, Bethlehem, Pennsylvania 18015.

Solid State / Sherman Fairchild Laboratory

Several solid-state research programs leading to the master of science and the doctor of philosophy degrees are available. The departments of chemistry, electrical engineering, metallurgy and materials engineering, and physics, and two interdisciplinary centers, the Materials Research Center and the Center for Surface and Coatings Research, participate in solid-state activities.

While degrees are granted by academic departments, arrangements may be made for students to carry out their thesis research in either research centers or academic departments, including departments other than their own.

In 1973 and in 1978 Lehigh was awarded grants totaling $6 million by the Sherman Fairchild Foundation for solid-state education and research. These grants provide the following: the Sherman Fairchild Laboratory, completed in 1976, a 16,800-square-foot building which now serves as the focal point of solid-state research activities at Lehigh; three endowed professorships, one each in physics, electrical engineering, and chemistry-materials; eight graduate fellowships; ten undergraduate scholarships, and funds for scientific equipment. One major facility available in this laboratory is a 3 MeV van de Graaff accelerator producing both electron and positive ion beams.

For further information, write to Professor W. Beall Fowler, Sherman Fairchild Laboratory #161, Lehigh University, Bethlehem, Pennsylvania 18015.

The Urban Observatory

The Urban Observatory is a unique and innovative effort to assist city officials in resolving the problems facing them today. It functions as a city center for the administration of research and strives to achieve a program of urban research which balances public officials' need for specific policy alternatives and academicians' desire to focus on and explain the underlying causes of urban problems.

Accomplishing this goal involves promoting interaction and cooperation between city hall and the academic community. The building of the institutional bridges which results from this city-university interaction is the heart of the Urban Observatory concept.

The Allentown Urban Observatory, located in City Hall in Allentown, Pa., works through Lehigh University to conduct a wide range of research on urban problems. Each year the Urban Observatory establishes a research agenda, with its policy board making the final decision on which projects will be carried out. This board consists of university officals as well as elected and administrative city officials.

Projects conducted to date have spanned a wide range of academic fields and university departments. Faculty, graduate students, and in some cases, undergraduates have been involved in social science projects such as an input-output model of Allentown's economy and a citizen participation study; industrial engineering projects such as productivity studies; civil engineering research such as storm water management modeling; business projects such as creating an accounting and reporting system for Allentown community development funds; and interdisciplinary, urban technology studies such as resource recovery and geocoding.

The Allentown Urban Observatory began as one of only ten smaller-city observatories scattered around the country. They were established in 1975 through the efforts of the National League of Cities after their initial program of ten large-city urban observatories had proved a success. Allentown Urban Observatory research projects have been funded by various federal, state and local sources; the original grant from the U.S. Department of Housing and Urban Development was administered by the National League of Cities. Currently, the City of Allentown provides the support for the Urban Observatory.

The fact that the university's involvement with the Allentown Urban Observatory is composed of discrete individual research projects means that this is not a degree program or a center for any one type or area of research. It also means that this program offers a unique opportunity to employ faculty and students in using the city as an interdisciplinary laboratory for testing technologies to solve urban problems.

For additional information, contact Dr. Joseph F. Libsch, vice president for research; Dr. Roy Herrenkohl, director, Center for Social Research; Professor Arthur F. Gould, associate dean, College of Engineering and Physical Sciences; or Dr. Arthur King, director, Urban Technology Program, Center for Social Research.

Research Centers And Organizations

Eleven interdisciplinary research centers, six institutes, and three other research organizations at Lehigh assist the academic departments in developing the full research and educational potential of the university in special areas.

The centers, institutes and other groups represent research thrusts based on the capabilities and interests of the faculty at Lehigh. Frequently, they relate to the broad-based research needs of government, industry and the social community.

The goal is to provide an effective interdisciplinary framework for programs involving faculty members and graduate students interested in combining traditional course programs with an interdisciplinary research experience.

The research centers, with the exception of the Center for the Application of Mathematics, the institutes and other research-related organizations, are administratively responsible to the vice president for research. The individual who holds this position, Dr. Joseph F. Libsch, has offices in Whitaker Laboratory. The Center for the Application of Mathematics is administratively responsible to the president of the university. Dr. Deming Lewis, who is a mathematician.

Research Centers

The research centers include the following: Center for the Application of Mathematics, Center for Economic Education, Center for Health Sciences, Center for Information and Computer Science, Center for Marine and Environmental Studies, Computing Center, Center for Surface and Coatings Research, Center for Social Research, Energy Research Center, Fritz Engineering Laboratory, and the Materials Research Center. Personnel associated with these centers are listed in Section VI.

Center for the Application of Mathematics

The Center for the Application of Mathematics was established in 1965 in order to foster interdisciplinary research related to the application of mathematics, to draw on other disciplines for pertinent mathematical problems, and to encourage the development of advanced courses in the application of mathematics.

The center surveys the need for courses in the application of mathematics and is concerned both with the design of new courses and the reorganization of existing courses so that these needs may be better served.

Research activities. Research programs are currently in their area of nonlinear continuum mechanics, the propagation of waves in nonlinear media, variational calculus, numerical analysis and biomechanics.

The program on nonlinear continuum mechanics includes fundamental studies in the formulation of continuum theories, the study of anomalous flow phenomena in viscoelastic fluids, the study of finite elastic deformations and stability, and the thermomechanics of materials in which irreversible processes take place and long-range forces may be present.

The program of nonlinear wave propagation includes fundamental mathematical studies of the propagation of both stress and electromagnetic waves in nonlinear media and the application of these studies in a number of areas of physics.

Both the work on variational calculus and that on numerical analysis are mainly directed to the solution of nonlinear elliptic differential equations. The work on biomechanics is concentrated on the study of transport phenomena in the microcirculation. This includes studies of capillary exchange, interstitial fluid movement and lymph flow, as well as the convection and diffusion of small ions and molecules within the interstitial space. Mathematical studies of the transport and convection of oxygen in the microcirculation also are being conducted.

Educational opportunities. Through the committee on applied mathematics, personnel of the center administer an interdisciplinary program leading to the degrees of master of science and doctor of philosophy. These programs are interdepartmental and stress the application of mathematics to the physical and social sciences.

For further information, write to the center's director, Professor Ronald S. Rivlin, 203 E. Packer Ave., Bethlehem, Pennsylvania 18015.

Computing Center

With a long heritage of teaching and research in the engineering and science disciplines, Lehigh has made extensive use of computers for more than a decade. In 1966, the need was recognized for an independent organization serving the diverse needs of the academic community, and the Computing Center was formed.

Today the center is charged with the responsibility of serving existing requirements while anticipating and preparing for the future requirements of its user community.

With its principal facilities located in Packard Laboratory, the Computing Center serves as a laboratory for departmental courses and research in computer theory and applications, including developmental programs. The center also provides computer services for all departments and centers of the university for solution of instructional, research and administrative problems.

In the summer of 1968, the center installed a Control Data Corporation 6400 computing system. The primary feature of this system are great computational speed and accuracy. Peripheral devices include over 700 million characters of on-line disk storage, a communications processor with capacity to support forty-five simultaneous interactive terminals, and two one-line plotters.

The principal programming languages available on the CDC system are FORTRAN, COBOL, PASCAL, BASIC, and COMPASS (assembler). Major applications packages such as SPSS, the BMDs and the IMSL subroutines are included in the program library.

In the fall of 1977, two computers were purchased from the Digital Equipment Corporation—a medium-size DEC 20 and a small PDP 11/34. The primary function of these computers is to provide additional time-sharing service to the Lehigh community. The DEC 20 has available the following programming languages: FORTRAN, COBOL, PASCAL, BASIC and MACRO (assembler). In addition, text editing and data base management software is provided. The PDP 11/34 supports programming in BASIC and a number of interactive, applications packages.

With these two new systems and the CDC 6400, the Computing Center can support more than eighty simultaneous interactive terminals. Five interactive terminal clusters and two remote batch terminal sites are located around the campus providing user access in addition to that available in Packard Laboratory.

Research activities. To preserve its role of impartial support for all users, the center does not engage in primary research. It has, from time to time, conducted research-related activities on its own or in cooperation with academic departments or research centers.

The Computing Associates Program, wherein the center provides the mechanism for industry and government to work with university faculty in the identification and solution of computer-related problems, is an example of such an ongoing cooperative activity.

The center was funded by the National Science Foundation as the lead institution of a regional, educational computing network. Ten educational institutions in the region utilize the Lehigh computer through its telecommunications facilities.

The center's primary role in research is to support the computing activities of the research community. Approximately one-quarter of the computer utilization is devoted to this activity.

Educational opportunities. Seminars on varied topics in computing are held or sponsored by the center for faculty, staff and students on varied subjects relating to data processing.

The center works closely with the Computer Society to meet the more independent inquiry needs of undergraduates, and the society's adviser is a member of the center staff.

Graduate students desiring a more intensive educational experience in an operating environment may apply for a graduate assistantship provided by the center.

Along with research, the center's primary method of offering educational opportunities in the use of computers is by providing computing resources for use by the academic community. The majority of jobs processed by the center are submitted by students as part of their normal academic activities. The growth of interactive processing facilities benefits these users primarily.

For further information, write to the director, Professor Ben L. Wechsler, Computing Center, 616 Brodhead Avenue, Lehigh University, Bethlehem, Pennsylvania 18015.

Energy Research Center

Energy research at Lehigh is a multidisciplinary activity, involving faculty and students from engineering, the physical sciences, life sciences, business and economics, and the social sciences. The Energy Research Center (ERC) is the focal point for this research, providing a structure within which faculty and students from different backgrounds can explore their specific research interests.

The center coordinates the university's energy research, helping the faculty respond to research opportunities and developments in energy. It is also the major contact between the university and industry and government for matters dealing with energy research. Originally founded in 1972 as the Task Force for Energy Research, ERC was organized into its present form in 1978.

The research within the center involves a wide range of topics related to the supply and use of energy. Work in progress—supported by contracts and grants from government, industry, and private foundations—deals with fuels and energy resources, energy conversion systems, energy conservation and the environment.

The Energy Research Center has particularly close ties with industry. A number of joint research projects involve Lehigh faculty and students and research staff from industry. The center also operates the Energy Liaison Program, through which participating companies and government facilities have access to faculty consultants, make use of laboratory facilities and library services, and receive assistance on research problems, feasibility studies and other projects related to energy. Through the center's Energy Intern Program, opportunities also exist for students to receive part of their training in industry. Through this program, a graduate student involved in energy can do a research internship in industry under the joint supervision of company research staff and the student's faculty adviser.

Experimental support for energy research is provided in a number of specialized laboratories maintained by the university. These laboratories, furnished with the latest instrumentation and equipment, include the following: boiling and two-phase flow, fluidized bed, physics of fluids, surface chemistry, chemical kinetics, GC/mass spectrometer, atomic absorption spectrometer, electron optical, mechanical testing, structural testing, welding, metal forming, fracture mechanics, ceramics, polymer, marine geotechnical, biological research, hydraulics and water resources, van de Graaff accelerator, and solid-state devices.

All faculty members who participate in Energy Research Center activities belong to university academic departments (for example, physics, mechanical engineering and mechanics, economics, and social relations). In addition, a number of faculty and staff members affiliated with the center have close ties with other on-campus research centers and institutes, assuring broad interactions between center personnel and experts from many research specialties, including economics, social science, materials and metallurgy, marine biology, fracture and solid mechanics, metal forming, structural design, sanitary and water resources engineering, thermal science, fluid mechanics, surface chemistry, and information science.

Energy Research

Research within the center falls within six major categories. Projects of current interest include:

Fossil fuels. Fluidized bed combustion of coal; heat transfer in fluidized beds; kinetics of coal gasification; fluidized bed gasification; dynamic simulation of coal conversion systems; kinetics of coal liquefaction; electrostatic precipitation of fly ash; hydrogen-enhanced crack growth in high-strength steels; mechanical properties of cryogenic steels for LNG applications; toughness of pipeline steels; fracture analysis of pipelines; mechanisms of tertiary oil recovery.

Nuclear technology. Instrumentation for reactor safety studies; boiling heat transfer in water-cooled reactors; deformation and densification processes in fuel rods; fracture toughness of reactor steels; static and dynamic fracture toughness of steel welds; pressure vessel design; high-energy particle physics; nuclear physics.

Environmental impact of energy systems. Oil pollution studies in the coastal and wetlands environment; effects of power plant operations on biological life in the New Jersey estuarine region; effects of heavy metal ions on subcellular coordination.

Energy economics. Dynamic analysis of energy supply-demand systems; model of an investor-owned electrical utility; peak-load pricing of electricity.

Conservation and Solar Energy. Performance of electric vehicles; fluidized bed heat exchangers for heat pump systems; studies of fuel derived from waste water treatment; energy recovery from municipal solid waste; energy conservation in the metal-forming industries; energy conservation in municipal governments; consumer response to peak-load pricing; phase change materials for thermal energy storage; integrated photovoltaic-wind energy power plants; analysis and design of solar collectors.

Energy-related offshore installations. Geotechnical propertis of the continental shelf and slope; offshore structure-soil interactions; stability of structural columns for offshore oil platforms.

Educational Opportunities

The extensive involvement of Lehigh University faculty in energy research has created a wide range of opportunities for graduate studies in energy. Most of the departments in the College of Engineering and Physical Sciences, as well as several departments within the College of Arts and Science and the College of Business and Economics, are active in energy research and offer both masters and doctoral degree programs suitable for studies of energy-related topics.

All degrees are granted by the academic departments (e.g., chemistry, mechanical engineering, government); and graduate students interested in energy enroll in traditional graduate degree programs in departments of their choice. These students specialize in energy by complementing their programs with a selection of special energy-related courses. They pursue their graduate research in energy areas under the supervision of faculty from the Energy Research Center or from other research centers or academic departments.

Opportunities also exist for students to receive part of their training in industry. With initial support from the National Science Foundation, Lehigh has developed a program in which a graduate student invovled in energy can do a reseach internship in industry under the joint supervision of company research staff and the student's faculty adviser. The Energy Intern Program is individualized: each internship is designed to meet the specific needs and interests of the student, the faculty adviser and the company.

Financial support for graduate students is available through the Energy Research Center by means of fellowships and research assistantships related to sponsored research.

Each year Lehigh faculty members offer a number of special energy-related courses at the undergraduate and graduate levels; many of them are outgrowths of current faculty research. Recent examples include courses dealing with energy economics, the international politics of oil, nuclear reactor engineering, fusion, air pollution, coal catalysis, coal technology, materials for modern energy systems, heating and cooling of buildings, solar energy, magnetohydrodynamics, and ocean engineering.

The Energy Research Center also sponsors an annual seminar series, bringing some of the outstanding people in the energy fields to the campus to speak. Covering a range of topics from economics to energy policy to science and engineering, these seminars provide an opportunity for faculty and students to learn of the developments in energy.

For more information, write to Professor Edward K. Levy, Packard Laboratory #19, Lehigh University, Bethlehem, Pennsylvania 18015.

Fritz Engineering Laboratory

Founded in 1909, Fritz Engineering Laboratory is involved in the advancement of knowledge and techniques in the fields of structures, structural mechanics, materials, hydraulics and fluid mechanics, geotechnics, and environmental engineering.

The laboratory is associated primarily with the department of civil engineering. In addition, there are cooperative research efforts with other departments and with other institutes and universities. Research projects are sponsored by national research councils, through the university Office of Research, and by industry and governmental agencies.

Graduate studies combined with research investigations commenced at Fritz Engineering Laboratory in 1928. A major expansion of the facilities in 1955 was followed by addition of equipment to meet the needs of new research opportunities.

The staff consists of faculty members, research associates, research assistants, and supporting technical personnel. The laboratory awards research assistantships and certain fellowships to competent research personnel who are candidates for advanced degrees. Students from departments and divisions such as civil engineering, metallurgy, mechanical engineering and mechanics, and information science are able to take advantage of research opportunities with the laboratory.

Through their work in research programs, individuals are trained for careers in teaching, in research, and in advanced engineering design.

Research activities. The current research divisions indicate present interests and activities of the laboratory staff and include the following:

Fatigue and fracture (brittle failure due to cyclic and impact loading); geotechnical engineering (soil, foundation, rock and pavement mechanics); hydraulics and environmental engineering (stream and channel flow, hydrology, sediment transport in pipes and channels, water quality control, water resources, and waste water treatment); building systems (behavior and strength of building components, frames and over-all systems, problems involved in the design of high-rise buildings, earthquake and wind responses); structural concrete (prestressed and reinforced concrete bridges and buildings); structural connections (welded and bolted joints, composite structures); and structural stability (buckling of plates, beams, columns and frames).

The operations division provides services for laboratory work, and includes an instrumentation group and a computer systems group, the latter maintaining close liaison with the university's Computing Center.

As a result of the research studies conducted by the staff of the laboratory, it has been possible to make basic changes to design procedures and specifications in many speciality fields. The laboratory participates in a worldwide exchange of research information, maintains a library of technical papers appropriate to its fields, and stimulates the publication of papers in technical journals both in this country and abroad.

Educational opportunities. Through the laboratory organization, technical seminars and lectures are presented on current research findings and on new design applications in the various fields of civil engineering and related disciplines.

Courses students select are primarily in their own department. However, to gain a broader understanding, many students choose courses from the departments of biology, chemical engineering, chemistry, civil engineering, geological sciences, industrial engineering, mechanical engineering and mechanics, and metallurgy and materials engineering.

For further information write to the director, Professor Lynn S. Beedle, Fritz Engineering Laboratory #13, Lehigh University, Bethlehem, Pennsylvania 18015.

Center for Health Sciences

The Center for Health Sciences, organized in 1972, is concerned with interdisciplinary research and graduate and postdoctoral training in various aspects of the biomedical sciences and engineering.

The center is comprised of four divisions: the Institute for Pathobiology, the Division of Biological Chemistry and Biophysics, the Division of Bioengineering, and the Division of Health Management and Policy Studies. Facilities are provided by these divisions for its members, postdoctoral fellows, and graduate students actively engaged in research in the respective areas.

A large part of the research conducted at the center is supported by private and public agencies and all are related to either basic or applied aspects of problems pertaining to human and animal life.

Research activities. The research opportunities and programs of each division are described below.

The Institute for Pathobiology

This institute, a branch of the Center for Health Sciences, is an interdisciplinary unit involved with research and graduate and postdoctoral education.

Fields currently represented in ongoing research projects include microbiology, protozoan and metazoan parasitology, invertebrate pathobiology, immunology, biological control, biochemistry, toxicology, epidemiology and epizootiology.

A number of current research projects are funded by both public and private agencies, including biological control and parasitological studies overseas.

The administrative offices and principal laboratories of the institute are housed in Chandler-Ullmann Hall. These facilities are well equipped for cytological, cytochemical, fine structural, immunological, physiological, biochemical, and tissue culture studies.

The following are some examples of research projects presently being carried out in the institute: possible biological control of invertebrate vectors of human and animal diseases by use of protozoan, bacterial, and viral pathogens; development of efficient molluscicides for the control of vectors of schistosommiasis and fascioliasis; studies on the intermediary metabolism and other phases of the biochemistry of helminth parasites; immunity to bacterial and parasitic diseases; diseases and defense mechanisms of marine organisms; and chemical changes associated with tumor development.

Division of Biological Chemistry and Biophysics

This research and graduate training unit is a part of the Center for Health Sciences. Fields currently represented in ongoing research include enzyme biochemistry, intermediary metabolism, medicinal chemistry, biosynthesis of organic molecules, the physical basis of surface adhesion in biological systems, clinical chemistry, effects of radiation on nucleic acids, nuclear medicine, radiopharmaceuticals, and biophysics of viruses. Much of the research is being funded from private and federal agencies.

The administrative offices of the division and most of the laboratories are housed in the Seeley G. Mudd Building. The laboratories are well equipped and the major pieces of equipment include infrared, ultraviolet, and visible spectrophotometers, nuclear magnetic resonance instrumentation, mass spectrometers, fermenters, gas and liquid chromatographic facilities, and other allied bioorganic apparatuses.

This division has an ongoing liaison program with Hahnemann Medical College and Hospital; clinical aspects of several research projects are being conducted there.

Division of Bioengineering

The research and graduate training unit of the Center for Health Sciences is concerned with a number of health-related

problems that are best resolved by individuals with a background in engineering.

Specifically, ongoing projects include measuring the rigidity and tension of healthy and diseased blood cells, the mechanics of flow through the mammalian circulatory system, the fracture mechanics of skeletal units, and the development of prosthetic apparatus and implant materials.

Most of the division's laboratories and its administrative office are housed in Packard Laboratory.

Division of Health Management and Policy Studies

This research and graduate training unit of the Center for Health Sciences is involved in research and other activities in the health sciences which go beyond conventional laboratory and field research and development.

Specifically, the staff and graduate students affiliated with this division are involved in a variety of studies including the management and economics of health services, the sociology and economics of aging, the history of medicine and public health, and the application of the computer in biomedicine.

Some of the ongoing projects within this division include: an analysis of the economic and sociological impact of schistosomiasis, management and economics of health services, information retrieval of data on the effects of drugs on humans, and the history of infectious diseases in the United States.

Educational opportunities. Graduate students working under the direction of members of various components of the center may satisfy their course requirements towards the master of science and the doctor of philosophy degrees by selecting from the offerings of the departments of chemistry, physics, biology, civil engineering, mechanical engineering and mechanics, as well as other departments of the university.

In addition, the interdisciplinary graduate program in physiological chemistry leading to the master of science and the doctor of philosophy degrees (see Interdisciplinary Study) is supported by the Center for Health Sciences although all of the students are enrolled in the department of chemistry.

In addition to research, the center sponsors symposia as well as an annual series of seminars on topics pertinent to its objectives.

For further information write to the director, Professor Thomas C. Cheng, Chandler-Ullmannn Hall #17, Lehigh University, Bethlehem, Pennsylvania 18015.

Center for Information and Computer Science

The information and computer sciences are concerned with principles and rules governing the organization, maintenance, transformation, and management of bodies of scientific, technical, and business information.

A major interest of information science is the problem of information transfer, which involves the communication of recorded information among originators, processors, and consumers. Information science has emerged as a response to this problem, and seeks to establish an organized body of knowledge based on explanatory principles governing the conditions under which events occur concerning the generation, transmission, and use of information.

The significance of establishing reliable principles of information transfer is directly related to the rapidly increasing importance of information-handling activities in society. Some fifty percent of the United States labor force is already invovled in the information sector, and the percentage is increasing. This situation has been heavily influenced by the truly remarkable advanced made in computers and communications technology, allowing processing of an increasing volume of material and a rapidly increasing variety of applications.

Information science and computer science are evolving disciplines with many common interests. One of the most important is to know how to use newly emerged and still-developing computer/communications technology in coping with problems that have affected society for a long time, but which are receiving increased attention. These problems are likely to become even more prominent as society shifts from industrial production to service activities.

Early recognition of the so-called "information explosion" led to the formation of the Center for Information Science in 1962 as a division of the university libraries. It was reorganized in 1967 as an independent center for research into information retrieval and for the development of information systems. A significant milestone was the design, development, and operation of the world's first information retrieval system providing on-line interactive access to the computerized data base of *Engineering Index*. The system is known as LEADERMART, because of its affiliation with the Mart Science and Engineering Library.

In 1978, the scope of the center was broadened to include computer science. The combination of the two activities and their substantial areas of common interest provide a platform for a wide variety of research projects.

Research Activities

The research and development activities of the center reflect current interests of staff members and include:

Fundamental research in information science. Studies in the structure of information; syntactical structures; semantic content; hierarchical retrieval structures; formal theories of information retrieval; the logical complexity of retrieval schemes; character recognition; pattern recognition; theories of information retrieval; formal grammars; computational and mathematical linguistics.

Fundamental research in computer science. Design of algorithms; properties of software; graph theory; theory of formal languages; automata theory; data and information structures; discrete mathematical structures; recursive function theory; computability and solvability; structured programming; compiler design; operating systems.

Behavioral research. Interfaces between people and information systems, learning and memory; human factors; psycholinguistics; cognitive processes.

Applied research in information and computer science. Simulation models of large-scale science information networks; management information systems; design of data base management systems; fact retrieval; new techniques of full text searching; interactive question-answering systems; knowledge transfer systems; computer-communication networks; systems analysis; artificial intelligence; numerical processing; communication protocols; scheduling.

Research facilities in CICS include a TERAK minicomputer, access to the CDC 6400, DEC 20 and PDP 11/34 computers, and remote computer terminals.

Educational Opportunities

The Center for Information and Computer Science is closely affiliated with the division of computing and information science in the department of mathematics (see Section V). Programs leading the the Bachelor of Science, Master of Science, and Doctor of Philosophy degrees are offered by the division. Opportunities exist for both graduate and undergraduate students to participate as research assistants and project assistants on sponsored research activities. Such activities provide graduate students with dissertation and thesis topics, as well as the use of computer terminals, minicomputers, and other facilities.

Seminars, short courses, and other educational programs are conducted periodically.

For information, contact the director, Professor Donald J. Hillman, Center for Information and Computer Science, Mart Library #8, Lehigh University, Bethlehem, Pa. 18015.

Center for Marine and Environmental Studies

Established in 1962, the Center for Marine and Environmental Studies (CMES) is a multidisciplinary center for research with the primary purpose of fostering research opportunities in marine science, ocean engineering and environmental studies. The staff includes faculty and gradute students from the departments of biology, chemistry, civil engineering, geological sciences, mechanical engineering and mechanics, and physics.

Effective utilization of the resources of the oceans requires the cooperation of many scientific and engineering disciplines. A good marine scientist is one well-trained in a basic field of science, i.e., biology, chemistry, geology or physics, who can apply the principles of a science to the understanding of complex interacting systems in the ocean. A good ocean engineer is one well-trained in a traditional engineering field who can apply engineering principles to problems unique to operations in the oceans.

Practical solutions for the many critical environmental problems facing the world will most likely be achieved through a combination of engineering and scientific talent. An environmental scientist or engineer needs a broad background in many disciplines, as environmental problems are invariably cross-disciplinary in nature.

Research activities. A broad spectrum of research activities is included within the center's scope. Although much of the research is carried out in facilities of the various academic departments, CMES has laboratories in Williams Hall (marine biology and marine geology), the marine geotechnical laboratory in Chandler-Ullmann Hall, and an off-campus marine station near Stone Harbor, N.J. (see listing for The Wetlands Institute, page 81).

Current research activities indicating present interests of CMES staff include: coastal salt marsh ecosystems; sublethal effects of pollutants on marine organisms; biological effects of thermal pollution; biochemistry of proteolytic marine bacteria; shallow water, near-shore sedimentation; deforma- of near-surface sediments at a subducting continental margin; alternatives to dredging (fluidization in tidal inlets); development of geotechnical instrumentation for use at sea; in-place measurement of geotechnical properties of sea-floor soils; marine slope stability; factors affecting development of shear strength in cohesive marine soils; effects of industrial and municipal pollution on rivers; advanced waste-water treatment methods; trace heavy metals in natural environmental systems; and mathematical modeling of weather phenomena.

Educational opportunities. Graduate students may undertake thesis or dissertation research in the Center for Marine and Environmental Studies to fulfill requirements for the master of science or doctor of philosophy degree in academic departments granting those degrees. Admission to the Graduate School and to candidacy for the doctor of philosophy programs are administered by the academic departments.

All faculty associated with the center are members of university academic departments and teach in their respective departments. The program of courses to meet the student's special field of interest and to satisfy departmental and graduate school requirements is arrived at by consultation with the academic department chairman or a special committee of faculty.

Courses in marine science, i.e., biological oceanography, marine geology, ocean physics, etc., are offered by the appropriate academic departments. Ocean engineering courses are offered by the civil engineering department. Courses related to environmental studies are offered by the departments of biology, chemistry, chemical engineering, civil engineering, and geological sciences.

Further information concerning educational opportunities may be obtained from the chairman of the prospective academic department, or from the director of the center, Professor James M. Parks, Williams Hall #31, Lehigh University, Bethlehem, Pennsylvania 18015.

Materials Research Center

The Materials Research Center was established in 1962. Currently, approximately 140 persons, including graduate students, research associates, and faculty members representing science and engineering departments, are engaged in research pertaining to materials science and engineering.

The fundamental objectives of the Materials Research Center are to encourage interaction among the science and engineering disciplines with an interest in materials and to promote interdisciplinary research activity and interdepartmental education opportunities. To achieve these objectives, the center seeks to establish a climate in which faculty members, research scientists, postdoctoral associates, and graduate assistants develop an awareness of materials; arrange for facilities and space required to conduct interdisciplinary research; guide the search for new materials by encouraging fundamental research and new approaches to materials problems; and assist in developing educational opportunities in materials—in particular, interdisciplinary graduate programs devoted to training for research in materials.

The center also conducts the Materials Liaison Program. Founded in 1963, this program promotes the interchange of knowledge between the materials community at Lehigh and engineers and scientists in industry and government. The program conducts day seminars on materials research, special lectures and workshops on items of current interest, consultation on materials problems and research, distribution of all master of science and doctor of philosophy theses, abstracts on materials research, and seminars with outstanding invited speakers.

The staff consists of members of the departments of chemistry, chemical engineering, electrical engineering, mechanical engineering and mechanics, metallurgy and materials engineering, and physics. Members of other departments and centers frequently are involved in cooperative programs. Communication with these associated units is achieved through the Materials Research Council, which is composed of senior faculty members from all of the engineering departments as well as from the department of geological sciences and appropriate centers. The council serves in an advisory capacity as well.

Research Activities. The present organization of the Materials Research Center includes five laboratories: the electronic materials laboratory, located in the Sherman Fairchild Laboratory; the electron optical laboratory, located in Whitaker Laboratory; and the ceramics research, mechanical behavior, and polymer laboratories, all located in Coxe Laboratory. Current interdisciplinary research activities include:

Electronic materials. Preparation and properties of materials for solid state devices; characterization of metal oxide films using optical and electrical methods emphasizing metal-insulator-semiconductor structures; defect structure and impurity interactions in amorphous and crystalline materials in both bulk and thin film form; interfacial segregation and phase formation in metal-oxide systems.

Electron Optics. Characterization of fracture surfaces in polymers and steels by scanning electron microscopy; x-ray

microanalysis of extraterrestrial materials, ferrous alloys, geological materials and ceramics using the electron probe microanalyzer; transmission and scanning transmission electron microscopy studies of grain boundaries in oxides; discontinuous precipitation in non-ferrous alloys; low-temperature phase transformations in iron materials; inclusions in weld structures of ferrous alloys; and glass metal reactions in lunar samples.

Ceramics. Deformation mechanisms, including creep and hot-pressing, and deformation mapping for ceramic materials; microstructural characterization of ceramic materials; thermal diffusivity and conductivity of refractory materials; preparation and characterization of nonoxide glasses; defect chemistry and electrical properties of ternary oxides.

Mechanical behavior. Effect of polymer chemistry and molecular structure on fatigue crack propagation (FCP); test frequency sensitivity and fatigue fracture micromechanisms in polymer solids; fracture characteristics of bridge steels; fatigue of weldments; corrosion fatigue crack propagation; metallurgical aspects of FCP in ferrous and non-ferrous alloys; fracture mechanism studies by transmission and scanning electron microscopy.

Polymers. Fatigue crack growth and relaxation processes in engineering plastics and composites; structure, morphology and mechanical behavior of interpenetrating polymer networks; thermosetting resins; vinyl polymers; polymers based on renewable resources; permeability and mechanical behavior of membranes, coatings, and filled polymers; novel polymer concrete systems.

Educational Opportunities. This center facilitates programs of study and research that cross the traditional boundaries of science and engineering curricula, providing a fundamental, broad approach to the field of materials science and technology.

Graduate students participating in the center's program usually receive master of science or doctor of philosophy degrees in the academic discipline of their choice, i.e., chemistry, physics, metallurgy and materials enginering, electrical engineering, etc.; or in an interdisciplinary program such as polymer science and engineering. However, they are expected to pursue coursework related to a broader understanding of materials and to conduct research on an interdisciplinary materials problem in one of the center's five laboratories.

Financial support for graduate students is available through the Materials Research Center by means of research assistantships related to sponsord research programs, and from the operating funds of the center.

For further information write to the director, Professor Donald M. Smyth, Coxe Laboratory #32, Lehigh University, Bethlehem, Pennsylvania 18015.

Center for Social Research

The Center for Social Research (CSR) is a multidisciplinary organization designed to stimulate, conduct, and communicate the results of research involving the social and behavioral sciences, particularly in relation to technology.

Several disciplines are involved in the activities of CSR: economics, political science, psychology, sociology, and international relations. Through externally funded projects, the center also cooperates with the university's other research centers, such as Fritz Engineering Laboratory, the Computing Center, and the Energy Research Center. Projects are conducted in cooperation with several science and engineering departments.

Founded in 1965 as the Center for Business and Economics, the focus of the center was later broadened and the name changed to the Center for Business, Economics, and Urban Studies. The center's early activities included research on economics and business forecasting, and on transportation problems. The change to include urban studies broadened the center's scope to encompass the disciplines of political science, sociology, and history. In 1972, the center's scope was further broadened to include behavioral science and international affairs, and the center's present name was selected as more accurately reflecting this broadened focus.

Research Activities

CSR's current programs of research and development are centered in four areas.

Behavioral research. Members of the departments of government, history, social relations, economics, and industrial engineering participate in the behavioral research program. Research interests focus on human behavior and include family dynamics and child-rearing practices, small group processes, environmental and community psychology, social motivation, and social attitudes. Other research has examined the effects of programs to alleviate social problems and the educational outcomes of programs in science education.

Business and economics. Members of the departments of economics, accounting and law, and management, finance and marketing in the College of Business and Economics participate in the business and economics program. Research interests are concentrated in the fields of public and corporate finance, international trade, labor policy, transportation, economic development, managerial economics, and economic theory. Also underway are studies of how to estimate the future costs and benefits of funding provisions of state and local retirement systems.

International studies. The international studies program includes faculty from the departments of international relations, psychology, biology, geology, economics, chemistry, government, and the Center for Information and Computer Science, Center for Marine and Environmental Science, and the Institute for Pathobiology. The objective of the program is to study issues which are technological in nature, international in scope, and which have policy-making implications. The program is designed to identify research priorities along the interface of science-based technology and the international system, to formulate relevant concepts, and to develop research techniques.

Urban technology. The urban technology program includes faculty from the departments of civil engineering, social relations, and government, and from the College of Business and Economics. The primary focus of the program is an integrated, interdisciplinary approach to current urban problems. The program serves as a visible liaison point for both city officials and university researchers. Current research efforts include energy conservation and cost-reducing methods for local government, the economic and technical feasibility of resource recovery, methane gas recovery and usage, storm water management, geocoding, and computer mapping.

Interdisciplinary Research

The social perspective of CSR's research activities is relevant to many facets of activity outside the university in local, regional, national and international affairs. Many research activities are based on a cooperative university-community relationship through which the research goals of CSR are achieved and community needs met.

Interdisciplinary research activities of CSR are currently being conducted in the following areas:

Energy conservation. Research related to energy conservation has become a major activity of CSR staff. Projects include a

program to aid municipal governments to achieve reduction in energy consumption and research on peak load pricing arrangements on residential electricity usage patterns.

Research on urban problems. The staff of CSR and other university faculty conduct a variety of research projects on urban problems. Many of these activities began as part of the Allentown (Pa.) Urban Observatory, originally funded by the U.S. Department of Housing and Urban Development through the National League of Cities. The projects are now carried on by the City of Allentown. Projects have included studies of municipal productivity, storm water management, water quality assessment, citizen participation, urban blight studies, and geocoding.

Other research on urban problems includes an economic, social and technical evaluation of the feasibility of resource recovery in the Lehigh Valley, and a study of municipal finance focused on actual and optimal use of debt by state and local governments.

Housing is the focus of another area of urban research. This activity, conducted in conjunction with the Lehigh-based Council on Tall Buildings and Urban Habitat, has involved a cross-national study of family responses to the high-rise residential environment and a study of occupants' perceptions of residential environments in general and high-rise buildings in particular.

Child development and family dynamics. The relationship between family dynamics and child-rearing has been the focus of several CSR studies. One study has examined family style and the ability to cope with the stresses of family life, comparing child-abusing with non-abusing families. A second study has examined the effects of a multidimensional service program on the recurrence of child abuse. These studies have been particularly concerned with factors that influence the quality of parent-child interactions.

Family health studies. The relationship between behavioral and environmental factors and health status is the focus of a three-county study of approximately 1,000 families.

Evaluation research. Program evaluation is the focus of several CSR studies. At the university, one study examines how a program to provide experience in industry to graduate students affects their perceptions of industry and industrial activity. A second study develops computer simulation models for use in higher education. The evaluation determines how the use of the models affects educational programs.

In the area of social service delivery there are two projects that involve the development and utilization of evaluation systems for client record-keeping, service accounting, and client progress evaluation. One is the evaluation of a child-abuse prevention demonstration program. The other involves the evaluation of services to the handicapped.

Research of aging. The center staff is currently exploring the potential for research related to aging. Several areas interest one or more of the Lehigh staff members affiliated with CSR: cognitive development associated with the aging process; the formulation of public policy with respect to aging; educational opportunities for the elderly; the process of coping with the crises inherent in aging; and the economics of retirement.

Educational Opportunities

All faculty associates of the Center for Social Research are members of university academic departments and teach in their respective departments. Graduate and undergraduate students from these departments are active in the center's research. The departments in most cases offer graduate degrees at the master's level; a few offer the doctorate.

Graduate training is conducted by the center in cooperation with those social science departments at Lehigh which offer graduate programs. The College of Business and Economics offers the master of business administration degree as well as the Ph.D. in business and economics. The government department offers the master of arts and master of public administration degrees, and the doctor of arts degree. The psychology department offers the doctor of arts degree. The social relations department offers the master of arts degree in each of three areas—anthropology, social psychology, and sociology. For further information on these programs, consult the relevant department description in Section V.

Financial assistance to graduate students is available through graduate research assistantships provided by research grants and contracts to CSR.

For further information, contact the director, Professor Roy C. Herrenkohl, Center for Social Research, 10 W. Fourth St., Bethlehem, Pa. 18015.

Center for Surface and Coatings Research

The Center for Surface and Coatings Research, which includes in its structure both the National Printing Ink Research Institute and the Emulsion Polymers Institute, was founded in 1966 in acknowledgment of the fact that surfaces and coatings are of basic scientific interest and technological importance.

Research in surface chemistry was initiated at Lehigh in the early 1940s and was broadened into the field of chemical coatings in 1946 when the National Printing Ink Research Institute began its activities here.Interdisciplinary research efforts gained strength in 1966 when a program on stress corrosion cracking was organized.

The purpose of the center is to make a coordinated, continuous and competent effort to understand complex surface and coating phenomena. Almost every aspect of life involves a surface; they are rarely bare, but are usually covered with a coating from the environment or from a prior treatment. Even in an ultra-high vacuum, certain minor elements in a metal have a preference for the surface and diffuse to surface sites. An understanding of the properties of surfaces accidentally or purposely applied coatings is vital to the electronic, chemical, petroleum, metals, and graphic arts industries.

Twelve faculty members from the departments of chemistry, chemical engineering, mechanical engineering and mechanics, and metallurgy and materials engineering are associated with the center. Ten of them have offices in Sinclair Laboratory. Three research scientists with backgrounds in chemistry and metallurgy are active in the center's research. CSCR is interdisciplinary in outlook and in fact.

Financial support for the center comes largely from research projects contracts with various industries and governmental agencies. Opportunities for cooperative sponsorship are provided by the center's liaison programs, whereby nonproprietary research is performed in areas of specific interest to the participating sponsors. Current liaison programs are concerned with surface and coatings science and emulsion polymerization. A Laboratory for Color Science is also cooperatively supported.

The center is well equipped with specialty instrumentation needed for advance research in its field. Sinclair Laboratory houses equipment for experimental studies employing flash desorption, Mossbauer spectroscopy, Auger spectroscopy, X-ray photoelectron spectroscopy, electron spectroscopy for chemical analysis, nanosecond fluorescence spectroscopy, ellipsometry, computerized spectrophotometry, microelectrophoresis, and continuous electrophoresis.

Other specialty equipment includes microbalances, testing machines for studies of environment-affected crack growth, gas adsorption and heat of immersion apparatus, wetting balances, apparatus for determining rheological properties,

and apparatus for the preparation of reproducible dispersions and films.

Research activities. The center's research program includes a broad range of topics vital to modern science and technology.

Some of the active topics are: optical and fluorescence studies of surfaces; zeolites; hydrogen-deuterium exchange; solid state chemistry of catalysts; mechanisms of catalytic reactions and development of new catalysts; wetting of multiphase systems; monodisperse oxides, characterization of surfaces; microelectrophoresis and continuous electrophoresis; electrophoresis under microgravity conditions; computerized color matching, estimation of color differences; color constancy and metamerism in coatings; light scattering in microvoids; Mossbauer spectroscopy of surfaces; erosion and wear, chemical composition of surfaces; passivity and corrosion inhibition; Auger spectroscopy; chemistry of fracture surfaces, hydrogen embrittlement; environmentally affected crack growth; adhesion of coatings; corrosion under coatings; water-based coatings; polymer surfaces; rate of drying of latex films; preparation of latexes by direct emulsification; particle size determination by hydrodynamic chromatography; rheology in non-Newtonian fluids; adhesion and flow of fluids in porous substrates; and photovoltaic effects in small particles.

The *Journal of Colloid Sciences* and *Advance in Colloid and Interface Science* are edited by Professor Albert C. Zettlemoyer.

Educational opportunities. CSCR is a facility in which graduate students undertake dissertation research leading to the master of science or doctor of philosophy degree in existing science and engineering curricula. Pertinent courses are offered in the departments of chemistry, chemical engineering, physics, mathematics, biology, metallurgy and materials engineering, and mechanical engineering and mechanics. A formal program in polymer science is active.

Potential and current graduate students whose interests are consistent with the center's objectives are welcome to associate with the research program and to avail themselves of the experimental facilities. Research assistantships are available. Since research topics are selected by mutual agreement, interested students are encouraged to explore research opportunities with the center's director.

The center's research also forms the basis of continuing educational programs designed primarily for industrial personnel. The conference center in Sinclair Laboratory accommodates the special seminars and short courses which are held periodically. Recent course topics include surface analysis, printing ink technology, emulsion polymerization, computer formulation of colorants, and paint removal.

The center provides opportunities for resident postdoctoral studies and for visiting scientists.

For further information, write to the director, Professor Henry Leidheiser, Sinclair Laboratory #7, Lehigh University, Bethlehem, Pennsylvania 18015.

University Institutes

There are nine institutes at Lehigh University. All but one were established since 1970; the newest, the Institute of Thermo-Fluid Engineering and Science, came into being in 1978.

The others are the Emulsion Polymers Institute, the Institute of Fracture and Solid Mechanics, the Lawrence Henry Gipson Institute for Eighteenth-Century Studies, the Institute for Metal Forming, the Institute for Pathobiology, the National Printing Ink Research Institute, the Institute for Research and Development in Education, and The Wetlands Institute.

Staff members of these institutes are listed in Section VI.

Emulsion Polymers Institute

The Emulsion Polymers Institute was established in 1975, provides a focus for graduate education and research in polymer colloids. Formation of the institute constituted formal recognition of an activity that had grown steadily since the late 1960s.

The institute is part of the Center for Surface and Coatings Research and has close ties with polymer and surface scientists in the Materials Research Center and the departments of chemical engineering and chemistry.

Polymer colloids or polymer latexes, as they are more commonly called, are finely divided polymer particles which are usually dispersed in an aqueous medium. Important products produced and utilized in latex form include synthetic rubber, latex paint, adhesives and paper coatings. The small particle size of typical latexes makes their colloid properties as important as the polymer properties for a number of applications. Hence the study of emulsion polymers is of necessity an interdisciplinary activity.

Research activities. Emulsion polymers research includes a broad range of problems in the areas of preparation, modification, characterization, and application of polymer latexes. Most commercial polymer latexes contain a number of important ingredients; some in only small quantities.

Research programs at Lehigh are aimed at understanding the function of recipe components during preparation and application of the latexes. The research projects are a blend of fundamental and applied efforts as well as a mixture of theoretical and experimental problems.

Significant research support for institute activities is obtained from industrial organizations through their membership in the Emulsion Polymers Liaison Program. Hence some considerble effort is made to relate the research results to industrial needs. Consequently, graduates can find opportunities for employment.

Educational opportunities. Graduate students in the institute undertake dissertation research leading to the master of science or doctor of philosophy degrees in existing science and engineering curricula or in the polymer science and engineering program.

Programs of study for individual students are designed to meet the student's interests, the requirements of the appropriate academic department, and the student's dissertation committee. Considerable flexibility is permitted in the selection of courses and a research topic.

Faculty members of the institute are involved in teaching normal university courses and continuing education courses for industrial personnel. The annual one-week short course, Advances in Emulsion Polymerization and Latex Technology, typically attracts about 100 industrial participants and twenty Lehigh students. This course is an important mechanism for developing meaningful interactions between institute staff and students and industrial scientists and engineers. Educational and research opportunities exist for postdoctoral students and visiting scientists as well as resident graduate students.

For further information write to Professor John W. Vanderhoff, Sinclair Laboratory #7, Lehigh University, Bethlehem, Pennsylvania 18015.

Institute of Fracture and Solid Mechanics

The Institute of Fracture and Solid Mechanics was established in the fall of 1970 to enable faculty members and students within the university to participate in research relevant to fracture and solid mechanics on a unique, interdisciplinary basis.

An area of special interest to the institute has been in fracture mechanics, which deals with the study of structural and material sensitivity to flaws. Such flaws can seriously affect the design and strength of ships, aircraft, automobiles, bridges and buildings. In the design of nuclear power plants, the incorporation of the fracture mechanics concept of safety in the presence of flaws is required. In addition, fracture mechanics is finding application in such areas as bone fracture, environmentally accelerated cracking of pavements and structural members, the fracture of rocks, and erosion of materials by solid or water particle impingement.

The institute centralizes many activities in the field of solid and fracture mechanics. These activities include: expansion of research capabilities to include the application of concepts of fracture mechanics to geology (rocks), medicine (bones), and composite materials; editing books on timely subjects in fracture and solid mechanics; compilation and collection of written materials to establish and maintain a special library of fracture mechanics; planning of conferences on fracture and solid mechanics; offering short courses and seminars on special topics; conducting liaison programs with industry and government agencies.

Research activities

There are several research programs being conducted in solid and fracture mechanics, sponsored by industry and governmental agencies. They include:

Fracture mechanics. Analytical: stress analysis of engineering structures weakened by flaws; spherical and cylindrical shells with mechanical imperfections; crack extension in viscoelastic and rate sensitive materials; thermoelastic analysis of crack problems; heat generation at the crack tip region in metals; vibration and impact of solids containing cracks; three-dimensional analytical and finite element studies of surface and through cracks; fracture behavior of layered and fiber-reinforced composites; elastic-plastic solutions of crack problems.

Experimental: static and dynamic fracture toughness testing of metallic, nonmetallic and composite materials; crack-extension resistance curve measurements for aluminum and titanium alloys and steels; glass-to-rubbery transition temperature in viscoelastic materials; velocity measurements of running cracks; fatigue crack propagation in pressurized shells and shells under membrane load; combined loading (biaxial, tension-bending, etc.) of thin plates with cracks; photoelastic studies of stress distribution in cracked and composite bodies; environmental effects on crack propagation under static cyclic loads; fatigue crack propagation under programmed loading; gaseous hydrogen embrittlement.

Solid mechanics. Analytical and numerical methods of analysis: conformal mapping technique applied to potential solutions; two- and three-dimensional asymptotic expansions near geometric discontinuities; integral transform solutions leading to Fredholm integral equations; singular integral equations with generalized Cauchy kernels; application of the Chebyshev and Jacobi polynomials; methods based on the Gauss-Jacobi quadrature formulas; special applications of numerical treatment and finite elements to continuum problems involving singularities; convergence of finite element solutions for continuum mechanics problems.

Plates and shells; development of advanced plate and shell theories; load-deflection and instability behavior of elastic and plastic shells of revolutions; composite and sandwich shells subjected to static and dynamic loadings; dynamics of magneto-elastic shells.

Educational Opportunities

Students interested in fracture and solid mechanics should refer to course offerings in the departments of mechanical engineering and mechanics, metallurgy and materials engineering, civil engineering, chemistry and biology.

For further information write to the director, Professor George C. M. Sih, Packard Laboratory #19, Lehigh University, Bethlehem, Pennsylvania 18015.

Lawrence Henry Gipson Institute for Eighteenth-Century Studies

The Lawrence Henry Gipson Institute for Eighteenth-Century Studies, established in 1971, serves as a memorial to one of America's most distinguished scholars.

It helps to support the research activities of the Lehigh community of humanists and social scientists interested in developing a further understanding of the period of history epitomized in Professor Gipson's monumental life work, *The British Empire Before the American Revolution* (15 volumes, written from 1936 to 1970).

Through its council, the Gipson Institute awards research grants and fellowships from the income of its endowment, a fund made possible by Professor Gipson's bequest of his entire estate to Lehigh. To further the scope of the original endowment, the council of the institute seeks additional support by promoting research and other programs related to the eighteenth century.

Research activities. The income from the endowment of the Gipson Institute, and other funds, provide faculty research grants to defray travel cost, microfilming, and other such expenses; graduate student grants to help support deserving students during their dissertation year; internal seminars to bring together the eighteenth-century interests of faculty and graduate students and to stimulate interdisciplinary research activities. These seminars are broad in scope and include faculty from neighboring institutions. Interdisciplinary graduate courses in eighteenth-century studies provide students, who normally concentrate on one discipline, with a grasp of other significant developments and an understanding of the rich cultural and intellectual milieu of the eighteenth century. Such courses stress the interrelationship of history, politics, literature, fine arts, philosophy, psychology, and the sciences.

Annual symposia honor Professor Gipson, involving distinguished scholars in eighteenth-century studies to lecture and also to discuss opportunities for further scholarly exploration. The Institute also provides additional research resources for the library; faculty fellowships for the pursuit of research in an eighteenth-century topic; and a national Lawrence Henry Gipson fellowship awarded on a competitive basis to a promising graduate student in eighteenth-century studies.

Educational opportunities. Among the academic departments involved in eighteenth-century studies are English, government, history, modern foreign languages and literature, art and architecture, music, philosophy, psychology, and social relations.

For further information, write to the coordinator, Professor Lawrence H. Leder, Maginnes Hall #9, Lehigh University, Bethlehem, Pennsylvania 18015.

Institute for Metal Forming

The Institute for Metal Forming, sponsored by the department of metallurgy and materials engineering, was established in 1970 to teach the principles and applications of metal-forming technology to graduate and undergraduate students; to provide instruction and equipment for graduate research in metal-forming processes; and to assist industry with solutions to problems in metal forming.

Metal-working processes are analyzed mathematically usually involving the computer. The results of the analyses are checked and refined by comparison with experimental data obtained in the fully instrumented metal-forming laboratories which are part of the institute's facilities.

In addition, an important part of the effort of the institute is the preparation of educational programs using the latest audiovisual techniques. These programs are used in the classroom and in institute-sponsored seminars on campus and at industrial facilities.

Long-range planning, together with major equipment acquisitions and construction, is supported by university funds, federal funds, and an industrial consortium.

Research activities. Current research areas include: hydrostatic extrusion; pressure-induced ductility; flow through converging conical dies; effect of holes, inclusions and pressure on tensile properties; friction measurement; cladding and forming of composite materials; forming of polymers; deep drawing, impact extrusion and ironing; powder consolidation.

Educational opportunities. Students interested in metal forming should refer to course descriptions in Section V for metallurgy and materials engineering and mechanical engineering and mechanics. In addition, the institute offers special informal seminars and lectures for graduate students.

For further information write to the director, Professor Betzalel Avitzur, Whitaker Laboratory #5, Lehigh University, Bethlehem, Pennsylvania 18015.

Institute for Pathobiology

The Institute for Pathobiology was established in 1971 as an independent unit. However, it became a division of the Center for Health Sciences when the latter was recognized in 1973.

The personnel affiliated with the institute are involved in research and graduate training in several aspects of the biomedical sciences. Specifically, the staff is concerned with research in the areas of microbiology, protozoan and metazoan parasitology, immunology, biological and chemical control of vectors of disease-causing organisms, toxicology, medical and public health ecology, and selected areas of developmental biology.

Research activities. Research currently being conducted at the institute include isolation and characterization of microorganisms potentially useful in the control of the snail transmitters of schistosomiasis, fascioliasis, and other helminthic diseases; the development of new specific molluscicides and insecticides; studies on the biochemistry and physiology of parasitic nematodes and trematodes with the objective of developing new chemotherapeutic compounds; examination of immune mechanisms in invertebrates;cell and tissue culture; isolation and characterization of toxins in edible marine animals; studies on the chemical basis of development of model organisms; and chemical changes in tumor cells.

Educational opportunities. Although graduate students participating in the interdisciplinary master of science and doctor of philosophy programs in physiological chemistry are enrolled in the department of chemistry, they are provided with research facilities and support by the Institute for Pathobiology as well as other divisions of the Center for Health Sciences.

For further information concerning graduate or postdoctoral research opportunities at this institute, contact Professor Thomas C. Cheng, director, Chandler-Ullmann Hall #17, Lehigh University, Bethlehem, Pennsylvania 18015.

National Printing Ink Research Institute

The National Printing Ink Research Institute (NPIRI) was established at Lehigh in 1946 to carry out fundamental research for the printing ink industry. It is Lehigh's oldest research institute.

In 1966, NPIRI was incorporated into the newly formed Center for Surface and Coatings Research because its activities formed an integral part of the center's area of interest. In 1970, NPIRI moved with the center into Sinclair Laboratory, which was built in large part with contributions from the printing ink industry.

The National Printing Ink Research Institute carries out fundamental research in its areas of specialization, i.e., application of the principles of colloid, surface and polymer chemistry to the broadest aspects of printing ink and paper, as well as to the printing process itself. Financial support comes principally from research contracts and grants.

Research activities. NPIRI's traditional areas of research are dispersion of pigments, rheology of printing inks, surface chemistry of lithography, printability, test methods, and instrumentation.

More recently, its research interests have expanded to include computer color-matching, safety and health aspects of printing inks, optical propeties of ink films, recycling of wastepaper, and ultraviolet light-cured inks.

Its laboratories are equipped with proof presses and test instruments to carry out work in these areas. Of particular interest is the Color Science Laboratory, which is equipped for all types of color measurement, and the Printability Laboratory, equipped to handle most printing problems.

Educational opportunities. The institute offers opportunities for graduate study leading to the master of science and the doctor of philosophy degrees. Its graduate students are drawn from the various academic departments and disciplines, e.g., the department of chemistry, chemical engineering, psychology, and polymer science and engineering.

NPIRI also offers undergraduate research opportunities, such as theses subjects tailored to individuals or programs involving several students. The 1974 National Science Foundation summer project on recycling of wastepaper, which involved six undergradutes, is an example of the latter.

Students who are interested in the institute's areas of specialization are welcome to associate with its program and to use its experimental facilities. Research topics are selected by mutual agreement between the student and the faculty adviser. Prospective students are encouraged to explore these opportunities with the institute's director.

NPIRI's other educational activities include a biennial Summer Course in Printing Ink Technology as well as meetings on special topics, e.g., Rheology of Printing Inks, Ecology in the Graphic Arts Industry, and Raw Materials Supply in the Printing Ink Industry. Other activities include the Test Methods Index, a compilation of test data applied to

inks and coatings, and Volumes I, II, and III of the Raw Materials Data Handbook, a compilation of the physical, chemical, fire hazard and safety hazard properties of the ingredients used in printing inks.

For information, contact the director, Professor John W. Vanderhoff, Sinclair Laboratory #7, Lehigh University, Bethlehem, Pennsylvania 18015.

Institute for Research and Development in Education

The Institute for Research and Development in Education was established in 1978 to encourage research in areas of education in which students and faculty have specific interests. Typical services provided include identifying and contacting funding sources, conducting literatures searches, assisting with budget preparation, and other research support.

The institute acts as a liaison between the researcher and such external agencies as the U.S. Department of Health, Education and Welfare, state departments of education, intermediate units and school districts. Agencies receive technical assistnce in the areas of training, program design, needs assessment, evaluation, and computer applications.

The institute is associated primarily with the departments of educational administration, curriculum and instruction, and human development in the School of Education, but it also cooperates with other departments, centers and institutes at Lehigh.

Research activities. The efforts of the institute are aimed at developing faculty resources to conduct research, training, and evaluation programs in areas of education associated with faculty interests in the three aforementioned departments. These interests include but are not limited to: school law; organizational behavior; school financing; cognitive development of children; language development; personality development; learning disabilities; psychometrics; minority assessment; counseling; biofeedback; reading; philosophical, sociological and historical foundations of education; violence and vandalism in schools; and the education of institutionalized populations.

Research in these areas is both theoretical and field-based. Its fundamental intent is to help educators deal with the problems they and their students face in the school and community.

Educational opportunities. Graduate students at both the masters and doctoral levels are encouraged to participate in faculty research. The institute provides three assistantships to qualified applicants from any department in the School of Education. In addition, departmental assistantships allow students to participate in the research efforts of the faculty.

For information, write to the director, Professor Raymond Bell, Institute for Research and Development, School of Education, Lehigh University, 526 Brodhead Avenue, Bethlehem, Pennsylvania 18015.

Institute of Thermo-Fluid Engineering and Science

The Institute of Thermo-Fluid Engineering and Science, established in 1978, provides a focus for the university's research and educational activities in fluid mechanics, thermodynamics, and heat transfer.

This institute seeks to consolidate the substantial ongoing research effort in these fields, to aid in the further development of such research, and to facilitate the utilization of this interdisciplinary strength in the university's educational programs.

Currently 21 full-time faculty and staff from the departments of chemical engineering, mechanical engineering and mechanics, and physics are among the institute members. Graduate students and undergraduates, as well as part-time and visiting staff members, join in the institute's activities.

Research facilities for thermo-fluids programs are based in the College of Engineering and Physical Sciences. Among the facilities available are laboratories for experimental investigations of fluid mechanics, gas dynamics, turbulent structure, solid-gas fluidization, boiling heat transfer and two-phase flow, refrigeration and heat pump systems, internal combustion engines, radiation and optical measurements, unit operations, and control dynamics. The university's Computing Center as well as various mini-computers are available for use in analytical computations.

The institute also conducts the Thermo-Fluids Liaison Program, to promote the interchange of knowledge between the researchers at Lehigh and the engineers and scientists in industry and government. In cooperation with companies participating in the liaison program, the institute's staff members seek to apply their specialized capabilities in thermo-fluids to current industrial and governmental engineering and scientific problems.

Research activities. The institute's staff members are involved in the three inter-related areas: fluid mechanics; heat transfer and thermal science; applied thermodynamics and modeling.

Combining experimental investigations with theoretical analyses, the researchers seek to understand and quantify the phenomenological mechanisms governing thermo-fluid processes. This knowledge is then brought to bear on relevant engineering problems of current concern in such applications as energy conservation, power production, coal conversion, aerodynamics, weather modeling, and nuclear energy.

The institute's current research program includes more than fifteen grants sponsored by industry and various governmental organizations. A wide spectrum of subjects are under investigation, including research on flow-induced vibrations, unsteady turbulent flows, solar and wind energy measurements, coherent turbulent boundary layer structures, blade flutter in compressors and fans, stochastic optimal control, application of finite elements for weather modeling, colloid size distributions by hydrodynamic chromatography, centrifugal fluidized combustion of coal, heat transfer in fluidized beds, heat pump systems, two-phase flow instrumentation, boiling heat transfer and two-phase flows, and nuclear reactor thermal safety.

Educational opportunities. Formal courses in fluid mechanics, heat transfer, and thermodynamics are offered in the College of Engineering and Physical Sciences. Institute staff members regularly teach both undergraduate and graduate courses in the departments of mechanical engineering and mechanics, chemical engineering, and physics. Undergraduates can select a program of study, in consultation with their adviser, with emphasis on thermo-fluid sciences by elective choices among the departmental offerings. A formal minor program in fluid mechanics is available. Graduate studies leading to the degrees of master of science or the doctor of philosophy with concentration in thermo-fluids are available in the three departments.

Participation by both undergraduate and graduate students in the thermo-fluids research activities is encouraged. Many undergraduates participate as individuals or as groups in term projects under the supervision of institute faculty members. This provides an opportunity for interested

students to obtain first-hand experience in pioneering thermo-fluids research. The research programs directed by institute staff members also provide support for graduate research assistantships, enabling selected graduate students to pursue their education and research in thermo-fluids on either a part-time or full-time basis.

In cooperation with various academic departments, the institute sponsors seminars by both staff specialists and by invited speakers from other institutions. These seminars are open to the university community, liaison program participants, and to engineers and scientists from neighboring industries. The institute anticipates organizing topical meetings, workshops, and short courses on specialized subtopics within the over-all discipline. Meeting topics will be selected to reflect ongoing research activities of the staff members and contemporary engineering concerns.

For information regarding the Institute of Thermo-Fluid Engineering and Science, write to the director, Professor John C. Chen, Packard Laboratory #19, Lehigh University, Bethlehem, Pennsylvania 18015.

The Wetlands Institute

This facility is a joint activity between The Wetlands Institue, incorporated as a nonprofit organization, and Lehigh Univesity. The university operates the institute under its Center for Marine and Environmental Studies.

The Wetlands Institute, which commenced operations in 1972, is located on a 34-acre site on the edge of a coastal salt marsh near Stone Harbor, N.J. It is a research and teaching field station. Following the practice of other seaside marine research stations, educators and researchers from other colleges and universities may use the facilities for research and education which falls within the general objectives of the institute.

These are to increase the understanding of the natural processes controlling the wetlands ecosystems through fundamental research; to investigate the renewability of the natural resources and to increase the biotic potential of the wetlands area; to ascertain the effects of disturbances caused by man's activities, and to find methods of minimizing these effects through practical and applied research; to provide factual scientific information which can serve others as a basis on which to make intelligent decisions for the long-range beneficial multiple use of coastal areas; to train scientists and engineers in methods of solving and of preventing problems in the coastal zones; and to educate the general public, both resident and vacationing, in the importance of wetlands to the general ecology of coastal areas, to the need for preserving and for enhancing the wetlands in maintaining those aspects of the coastal zones that make them attractive to residents and vacationers, and what each person can do to protect the environment.

The Wetlands Institute provides facilities for year-round studies of the surrounding environment and includes six research laboratories, dormitory space and kitchen facilities, lecture room and demonstration area, flowing salt water system, maintenance shop, scientific laboratory equipment, and outboard motor skiffs.

Research activities. Current research interests include: salt marsh food webs; physiological criteria for determining sublethal effects of various environmental parameters; sedimentation studies; geochemistry of coastal salt marsh waters; beach sand studies; microbial mineralization of cellulose and chitin in salt marshes; new techniques for identification of planktonic fish eggs; viral diseases of fish; effect of sewage on marine organisms, and oil pollution studies.

Educational opportunities. Formal graduate studies are offered through the graduate programs in various departments of the university.

One facet of graduate student training is related to preparation of scientists to continue studies of the coastal area; the other is concerned with providing school science teachers with sufficient training so that they are able to return to the classroom and pass on vital information about the tidal wetlands to their students.

In conjunction with teacher training, every effort is made to provide lectures, demonstrations and tours of the wetlands for classes. Selected undergraduate courses also are offered as part of the summer program.

For information, write to the director, Prof. Vincent G. Guida, 106 Chandler-Ullmann Hall #17, Lehigh University, Bethlehem, Pennsylvania 18015.

Research Organizations

In addition to the diverse research and educational entities of the university which are described in the preceding section, Lehigh has three other organizations which have special functions and which do not fit neatly into the other categories. They are described forthwith.

Educational Service Bureau

The Bureau of Educational Service was organized in 1953 to provide professional assistance to public and private schools and various other educational groups.

The bureau renders professional assistance to educational institutions by a cooperative study of their problems, fostering research in the field of educational practice, and helping to make the resources of the university more readily available to communities and agencies in need.

In fulfilling these purposes, the bureau obtains the services of specialists from all areas of the academic profession.

Detailed information concerning assistance with specific problems can be secured from Professor LeRoy J. Tuscher, School of Education, Lehigh University, 524 Brodhead Ave., Bethlehem, Pennsylvania 18015.

Office of Research

The Lehigh Institute of Research was organized in 1924 to encourage and promote scientific research and scholarly achievement in every division of learning represented in the university, and in recognition of the need for further and more exact knowledge in science and in the appliction of science to the affairs of modern life.

The institute was reorganized in 1945 in recognition of the increasing role of governmental agencies and industry in sponsoring research, and renamed in 1968 in recognition of its administrative function.

Structural Stability Research Council

The Structural Stability Research Council has had its headquarters in the Fritz Engineering since 1966. It was

organized in 1944 by the Engineering Foundation.

The purpose of the council is to maintain a forum where problems relating to the design and behavior of columns and other compression elements in metal structures can be presented for evaluation, and where pertinent structural research problems can be proposed for investigation. Membership includes 200 specialists from universities, industry, and government. Sponsoring and participating organizations are involved with design and with codes and specifications.

The council's major publication is the *Guide to Stability Design Criteria for Metal Structures*, now in its third edition, a critical digest of the world's literature in the field.

Various Fritz Engineering Laboratory research projects receive the guidance of the council's advisory committees. Results of past research as well as problems requiring further study are reviewed annually at the council's annual technical session and meeting. For more detailed information, contact Prof. Lynn S. Beedle, director, Fritz Engineering Laboratory #13, Lehigh University, Bethlehem, Pa. 18015.

Council on Tall Buildings and Urban Habitat

The Council on Tall Buildings and Urban Habitat, an international activity sponsored by engineering, architectural and planning professionals, was established in 1969 to study and report on all aspects of the planning, design, construction, and operation of tall buildings. A major focus of the council is a comprehensive monograph, first published in 1978, for use by those responsible for planning and design of tall buildings.

The council is not an advocate for tall buildings, *per se*; but in those situations in which such buildings are viable, it seeks to encourage the use of the latest knowledge in their implementation. The council is also concerned with the impact of tall buildings on the urban environment and in the role they play in urban life. This involves a systematic study of the problem of providing adequate space for life and work, considering not only technological factors, but social and cultural aspects as well.

The headquarters of the council is at Lehigh University. Nearly 2,000 specialists, primarily engineers, architects, planners, and sociologists from seventy countries, are involved in the work of its committees. A number of these committees provide advisory guidance for relevant Lehigh research projects.

In addition to the monograph, important activities include the identification and stimulation of needed research and implementation of findings into codes, specificaions, and standards. For more detailed information, contact Prof. Lynn S. Beedle, director, Fritz Engineering Laboratory #13, Lehigh University, Bethlehem, Pennsylvania 18015.

Academic Centers

Center for Economic Education

The Center for Economic Education was established in 1976. It is part of a nationwide network of more than 150 such centers under the guidance of the Joint Council for Economic Education.

For over a quarter of a century the Joint Council has been involved in programs to reduce the level of economic illiteracy in the United States. The purpose of the Joint Council Lehigh Center is to increase the quantity and improve the quality of economic education.

Located in Drown Hall, the center is part of the College of Business and Economics. But it takes on an interdepartmental role as it coordinates programs aimed at heightening understanding of the American business and economic system. The center serves as a clearing house for educational ideas. It also houses an expanding resource library including books, films, filmstrips, curriculum material, testing packets, and simulation games for use by faculty and area educators.

Research activities. The major goal of the Center is not primary research. Still the Center is undertaking need assessment studies to establish priorities for economic education programs. The Center is involved in projects to determine effective teaching strategies and testing procedures. In addition to this the Center serves to direct programs which involve faculty in projects designed to explore areas of concern such an energy economics, law and economics, capital formation, etc.

The major focus of the Center revolves around community-oriented programs. These programs are designed to improve economic understanding by giving individuals the tools to deal with economic problems and concepts. Included among these programs are in-service activities for teachers in area schools, assistance for school curriculum development, preparation and distribution of educational materials, an economic education newsletter, and economic workshops for community groups.

Educational opportunities. An integral part of the Center's operation is a summer institute for teachers. The institute is designed to give teachers from all levels both the basics of economics as well as assistance in incorporating these concepts into the classroom. The summer institute features courses taught by Lehigh faculty and individualized workshop sessions with education specialists. Participants receive college credit for the institute and may enroll in an ongoing summer program leading to the master of arts in economics degree.

Each semester one or two undergraduates work with the center director on projects ranging from research into the teaching of economics to compilation of information for the publication of a newsletter. Other students are involved in the development of campus-wide economics programs.

The center also sponsors workshops, seminars and guest lectures designed to meet the educational needs of faculty and students. Sessions such as the American Iron and Steel Industry Economic Seminar allow members of the Lehigh community to meet with academic and business leaders to discuss specific economic issues relating to the industrial process.

For further information, write to the center's director, Prof. Bruce R. Dalgaard, Center for Economic Education, Drown Hall #35, Lehigh University, Bethlehem, Pennsylvania 18015.

Small Business Center

The Small Business Center was established in 1977 for the benefit of students, faculty and owners of small businesses in the Lehigh Valley. The function of the center is to bring together in one location the skills and expertise of faculty and students with the information and resources of the various levels of government in one location for easy access by the small business community.

The center involves students in a practical learning experience as counselors to business and planners of new

ventures. Counseling is provided through LUMAC (Lehigh University Management Assistance Counseling), a three-credit, graded course offered each semester. Approximately fifty businesses are served each year through the efforts of ninety students each semester. The center also provides services through the Lehigh Valley chapter of SCORE (Service Corps of Retired Executives).

The center conducts studies regarding problems faced by small business and the impact of the general economy on the problems of the formation and operation of small business. The center also studies characteristics of entrepreneurs.

For further information, write to the center's director, Prof. John W. Bonge, Small Business Center, 412 S. New St., Bethlehem, Pennsylvania 18015.

Continuing Education

Lehigh University offers a varied selection of continuing education programs for adult learners. Reflecting Lehigh's educational strengths, these activities are largely in the areas of career development, sophisticated technical training, and university-level cultural and personal growth experiences.

Continuing education programs at Lehigh neither carry academic credit nor require matriculation into the regular degree programs of the university. Instead, they are self-contained educational experiences, designed to meet the needs of specific adult groups. For this reason, their content, schedules, and timing can be adapted to best serve the audiences for which they are developed. Instructors are generally drawn from Lehigh's permanent faculty, but, on many occasions, distinguished men and women from outside the university are added.

Individual departments and research centers at Lehigh have presented such continuing education programs for decades, establishing a reputation for excellence and utility. Now the university has established an office of continuing education to serve as a central contact and coordination point. If you wish to receive information on current Lehigh continuing education programs, contact the Office of Continuing Education, Sayre Building, Lehigh University, Bethlehem, Pennsylvania 18015.

A day's run of early-model Packard pickup trucks returns after a test drive. Wouldn't these be a hot-selling item today?

V. Description of Courses

This section includes listings of undergraduate and graduate courses offered by Lehigh University. For purposes of record, all approved courses are listed. It must be understood, however, that the offerings in any given semester are contingent upon a number of factors, including student needs as determined at the time of preregistration.

Credit Hours

The number in parentheses following each course title indicates the credit value of the course in terms of semester hours. Three hours of drawing, of work in the laboratory, or of practice in the field are regarded as the equivalent of a recitation or lecture of one hour's duration.

Course Numbering

The course numbering system specifies which courses can be applied to the program of study as the student progresses toward the undergraduate or graduate degree. In general, the numbering series is as follows:

0-99. Undergraduate courses, primarily for underclassmen. Not available for graduate credit.

100-199. Undergraduate courses open to freshmen on petition. Not available for graduate credit.

200-299. Courses open to advanced undergraduates and graduates. Not available for graduate credit in the major field.

300-399. Courses open to advanced undergraduates and graduates. Available for graduate credit in the major field.

400-499. Courses open to graduate students only, and undergraduates by petition.

Provisional Courses

Each instructional department is authorized to offer provisional courses, or those offered on a trial basis, as well as special opportunities courses. Such courses become a permanent part of the university curriculum. These courses are numbered, as is appropriate, . . . 97-98, . . . 197-198, . . . 297-298, . . . 397-398, for a maximum of two semesters.

Students may take 97-98 courses pass/fail under the standard procedures for pass/fail.

Apprentice Teaching

The apprentice teaching program is designed to benefit students with junior or senior standing who want to learn about teaching under the guidance and supervision of an experienced teacher. The apprentice receives instruction and

experience in many aspects of the teaching process while working with the master teacher in a course taught by the master teacher.

Master and apprentice teachers are responsible for submitting to the departmental chairperson an outline of the activities in which the apprentice will participate. The outline must be approved and kept on file. Apprentices typically receive three hours of credit for regularly attending classes, doing a limited amount of observed lecturing or leading of discussions, assisting in making up and evaluating some written assignments, and being available for individual consultation with students.

Apprentice teachers should have an over-all cumulative grade-point average of 2.8 or better or a cumulative gradepoint average of 3.2 in the major field in which the apprentice teaching is done, and should previously have taken for credit the course in which they will apprentice or its equivalent. A student may register for apprentice teaching only once each semester, and only twice during the college career, for a total of not more than six hours of credit. The student may register to be an apprentice teacher in a given course only once.

A graduate student who is not a paid teaching assistant may register for apprentice teaching, but the department decides whether the student may receive credit which will count toward fulfilling requirements for a graduate degree. The apprentice is graded for work in the course by the master teacher.

Students who wish to do apprentice teaching in extradepartmental courses, such as those offered as Freshman Seminars, may do so with the approval of the director of the program. In high immediate relevance courses or courses cross-listed in several departments, the approval of the chairman of the department which offers the course is required. In such cases, the student registers for the 300-level course with the same heading as the course in which he or she is an apprentice (e.g. FS 300, Apprentice Teaching in FS 97C).

This program carries the following provisions: except with the college dean's approval, professors do not accept more than two apprentice teachers per semester; master teachers supervise all aspects of the apprentice's work; the duties of the apprentice teacher are restricted to those which will provide a learning experience for the apprentice without inhibiting the educational experience of students taking the course; the duties of apprentice teachers are not to be confused with those performed by paid graduate teaching assistants; and the master teacher provides a report on the apprentice teaching experience to the departmental chairperson and to the dean of the college.

Prerequisites

Academic preparation required for admission to courses is indicated under "prerequisites" following course descriptions. Prerequisites are stated in most cases for purposes of convenience in terms of Lehigh courses. Status required for admission, where numbering does not fully describe this status, is also indicated under "prerequisites."

A student who does not have the status or the academic preparation set forth as prerequisites must, in order to be admitted to a course, file with the registrar at the time of registration and on a standard form provided, a waiver of prerequisites signed by the head of the teaching department, and the student's curriculum director. Academic work completed elsewhere must be attested in this manner as being substantially equivalent to prerequisites listed, unless the student's records in the office of the registrar show that the proper officers have so evaluated this preparation previously.

English 2, 4, 6, 8 and 10 are prerequisites to all 100- or higher-level courses. Exceptions may be made only by petition to the committee on standing of students.

Abbreviations

Whenever possible, course listings contain information indicating what requirements the course satisfies, the semester or semesters in which it is offered, and the name of the scheduled instructor.

While all information herein is subject to change, the information is included to help guide the student in the selection of appropriate courses that best fulfill the student's academic and personal requirements.

The symbols following course titles for some College of Arts and Science courses include:

P. Courses that meet preliminary distribution requirements.

UP. Courses that meet upperclass or preliminary distribution requirements.

NS. Psychology department courses that meet the Natural Science distribution requirments.

SS. Psychology department courses that meet the Social Science distribution requirements.

Faculty Identification

In many cases, the names of professors scheduled to teach a course are listed at the conclusion of the course description entry. In most instances, those identified in this way are listed as faculty members in the introductory section to each department. In a few cases, however, the teacher of a record may be associated with another department. In any case, identification of the individual and his or her credentials may be found in the alphabetical listing of faculty in Section VI.

Information Limits

The course descriptions are intended to guide the student in selecting appropriate courses. For reasons of space, descriptions are brief. In most cases, courses will offer much more than the items listed in the description. In some courses, material may change from what is described. If there is doubt concerning the appropriateness of any course for the individual's educational objectives, it is advised that the student confer with the adviser.

Accounting and Law

Professors. Carl L. Moore, M.A., C.P.A., *chairman*; Brian G. Brockway, LL.B., LL.M.; Alfred P. Koch, M.S., C.P.A.; Frank S. Luh, Ph.D.; Robert H. Mills, Ph.D., C.P.A.; James B. Hobbs, D.B.A.
Associate professor. Kenneth P. Sinclair, Ph.D.
Assistant professors. Dunham R. Bainbridge, Ph.D., C.P.A.; John W. Paul, Ph.D., C.P.A.; Lamont F. Steedle, Ph.D.; James W. Tobak, M.A., J.D.; Stuart K. Webster, Ph.D., C.P.A.
Instructor. Robert W. Parry, Jr., M.B.A.

The Accounting Major

The program is offered in the College of Business and Economics. Required: 15 credits beyond core requirements.

Acctg 315	Financial Accounting I (3)
Acctg 316	Financial Accounting II (3)
	accounting electives (except Acctg 390) (9)

Note: Students interested in qualifying for Certified Public Accountant (CPA) or the Certificate of Management Accounting (CMA) at either the bachelor or master of business administration level should consult the chairman of the department or their major adviser. The accounting and law program has been designed so that it will meet the five-year study requirement of New York State.

Undergraduate Courses

51. Essentials of Accounting (3) fall-spring
The organization, measurement and interpretation of economic information. Introduction to accounting theory, concepts and principles, the accounting cycle, and information processing. Exposure to controversial issues concerning income determination and valuation. Prerequisite: sophomore standing.

52. Essentials of Accounting (3) fall-spring
Financial statement analysis for managerial and external use. The use of economic information for managerial planning and control. Introduction to job order, process, and standard cost accounting, variable costing and volume-mix-price-cost relationships. Prerequisite: Acctg 51.

108. Fundamentals of Accounting (3) fall-spring
A one-semester survey of accounting principles and practices, including an introduction to industrial cost systems designed for those students planning to take only one accounting course. Other students should take the Acctg 51-52 sequence.

111. Computers in Business (3) fall-spring
An introduction to computers with emphasis on business applications. Students develop a working knowledge of a computer language sufficient to solve business problems. Basic knowledge of hardware, software, error control, integrated systems, and simulation. Not open to students who have had a previous equivalent course (normally three credit hours) in computers.

For Advanced Undergraduates and Graduate Students

300. Apprentice Teaching in Accounting (1-3)

307. Federal Tax Accounting (3) fall-spring
An introductory exposure to the federal income tax laws, rules, and regulations applicable to income tax determination of individuals, partnerships, and corporations. Tax planning and timing of transactions is emphasized. Prerequisites: Acctg 51 and 52. Koch

309. Federal Taxation of Business Associations (3)
The theory, policy and law pertaining to federal taxes involving partnerships, corporations, estates and trusts. Problem solving, research, and planning are emphasized. Prerequisite: Acctg 307. Brockway, Koch

311. Accounting Information Systems (3) fall
A general introduction to the development and implementation of an electronic data processing accounting information system. The course considers the tools and techniques used by someone performing the systems function. Prerequisites: Acctg 52 and Acctg 111. Luh

315. Financial Accounting I (3) fall
Intensive study of the basic assumptions and principles of accounting, the accounting process, and problems concerned with presenting fairly the financial position and operating results of business entities. Consideration of the measurement of current assets, current liabilities, noncurrent assets, long-term debt, and preparation of financial statements. Prerequisites: Acctg 51 and 52. Bainbridge, Webster

316. Financial Accounting II (3) fall-spring
A study of generally accepted accounting principles and problems concerned with presenting fairly the operating results, financial position and changes in financial position of business entities. Consideration of shareholders, equity, partnerships, earnings per share, tax allocation, pensions, leases, and price level changes. Preparation, analysis, and interpretation of financial statements. Prerequisites: Acctg 51 and 52. Bainbridge, Webster

317. Advanced Accounting (3) spring
Problems of business combinations and consolidations, fund accounting as it applies to not-for-profit entities, foreign exchange, and fiduciary accounts. Prerequisite: Acctg 315 or 316. Luh

320. Auditing (3) fall
Survey of auditing theory, objectives, and practices relating largely to the responsibilities of independent professional accountants; ethics of the profession, generally accepted auditing standards, internal control, examination of various systems including EDP, statistical methods, report writing, etc. Prerequisite: Acctg 315. Paul

324. Cost Accounting (3) spring
Principles and practices of industrial cost accounting, including cost planning and budgeting, cost controls, job-lot and standard and process systems, variance analysis, performance reports, costs in management decisions. Prerequisite: Acctg 52.

371. Directed Readings (1-3)
Readings and research in various fields of accounting; designed for superior students who have a special interest in some topic or topics not covered by the regularly rostered courses. Written term paper(s) required. Prerequisite: preparation acceptable to the instructor.

372. Special Topics (1-3)
Special problems and issues in accounting for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of instructor and students. Prerequisite: preparation in accounting acceptable to the instructor.

390. Internship (3-6)
Designed to give advanced students of accounting, who have maintained a satisfactory standard of scholarship and who show promise in the field of accounting, an opportunity to acquire field experience and training with selected industrial or public accounting firms or governmental agencies as a complement to the academic learning process. Outside readings are assigned. Written reports are submitted by employer and students. The amount of credit is influenced by the length of the training period and the character of the experience afforded to the trainee, but does not exceed six hours for a regular semester or three hours for a summer period of at least eight weeks. Prerequisite: junior standing and approval of the faculty committee on internship.

Accounting for Graduate Students

A CPA Review Course (without credit) is available to seniors on a voluntary basis in the spring semester. The specialized accounting courses at the 300 level are frequently offered in graduate sections in addition to the 400-level courses. These graduate offerings permit master of business administration students to take a limited concentration of nine to twelve hours in accounting. If they have taken twelve to fifteen hours in accounting as undergraduates, their total professional preparation of 21 to 27 hours represents a sound basis for a career in public, industrial or governmental accounting. Undergraduates may wish to plan ahead for a full five-year program including the master's degree for professional accounting preparation. Note: Students with more than six credit hours of undergraduate accounting (excluding Acctg 111) must take a 400-level accounting course other than Acctg 422. For information about CPA requirements in different states, the CMA certificate, or for the selection of accounting electives, consult the department chairman.

401. Legal Problems in Business (3) fall-spring
Specific legal problems involved in making business decisions. Emphasis is placed on preventive law and the tax consequences of business transactions. Prerequisite: Law 403, Fin 401. Dower

403. Commercial Transactions and Business Organizations (3)
The study of the law of contracts, especially as it applies to the sale of goods; and the study of the law of agency, partnerships and corporations. This course is designed to meet this background requirement of a student enrolled in the MBA program. Prerequisite: Acctg 415.

406. Advanced Tax Planning and Research (3) spring
An advanced course in federal tax laws, rules, and regulations involving cases and problems relating to various tax entities. Tax planning and utilization of research tools is emphasized. Prerequisite: Acctg 307. Koch

408. (IE 408) Management Information Systems (3)
Integrated and total systems concepts for organizational data bases and information systems as applied to planning, development and implementation of computer-based management information systems. Emphasis placed on the interaction of information systems with management planning and control. Prerequisite: an advanced course in information systems and a knowledge of programming.

411. Computers and Management (3)
The role of computers in the operation, control, and planning of a business. Uses of computers in recurring operations, problem-solving and decision-making. Basic knowledge of computer hardware and software. System life cycle and the role of managers in system development. Students develop a working knowledge of a computer language sufficient to solve business-related problems with batch and interactive processing. This course is designed to meet this background requirement of a student enrolled in the master of business administration program.

415. Financial Flows and Accounting Measurements (3)
Basic financial accounting theory as a general frame of reference for understanding and evaluating accounting procedures. An introduction to the accounting interpretation with an exposure to controversial issues concerning income determination and asset and equity measurements. Open only to graduate students who have not had a previous course in financial accounting. This course is designed to meet this background requirement of a student enrolled in the master of business administration program.

422. Managerial Accounting (3) fall
Survey course for non-accounting majors (related course for accounting majors is Acctg 324); uses of accounting data for managerial planning and control, including cost control; capital expenditure planning; product pricing decisions; operations research applications. Prerequisite: Acctg 51. Moore

424. Advanced Management Accounting (3) spring
Managerial planning and control problems with emphasis on the responsibilities of the accountant. Practical applications using cases. Includes advanced treatment of management control systems, managed costs, transfer pricing, and the capital investment problem. Prerequisite: Acctg 324 or 422. Luh, Sinclair

426. Advanced Problems (3) spring
Advanced problems and cases in the formation, transfer of ownership interests, operation, and liquidation of various forms of business entities; government accounting; foreign exchange. Prerequisites: Acctg 315 and 316 and permission of chairman.

431. Accounting Theory and Thought (3) fall
A critical and historical examination of modern accounting concepts. Concerned with measuring enterprise income and capital and related economic data, in both simplified and realistic circumstances, and with communicating and interpreting such data effectively to interested parties. Prerequisite: 15 hours of accounting.

442. Professional Accounting Seminar (3) spring, alternate years
Survey of technical and professional accounting problems at the advanced level. Advanced case studies in public accounting and management services. Prerequisite: 15 hours of accounting.

471. Directed Readings (1-3)
An extended study of an approved topic in the field of accounting. May be repeated.

472. Special Topics (1-3)
Special problems and issues in accounting for which no regularly scheduled coursework exists. When offered as group study, coverage will vary according to interests of instructor and students. Prerequisite: preparation in accounting acceptable to the instructor. May be repeated.

471. Directed Readings (1-3)
Graduate readings in law not covered in regularly scheduled courses. When offered as group study, coverage varies according to the interests of the instructor and students. Prerequisite: consent of department chairman. May be repeated.

472. Special Topics (1-3)
Special problems and issues on law for which no regularly scheduled graduate course work exists. When offered as group study, coverage varies according to the interest of the instructor and students. Prerequisite: consent of department chairman. May be repeated.

Undergraduate Courses in Law

Note: Accounting courses 401, 403, 471 and 472 also relate to law.

11. Introduction to Law (3)
A study of the nature and function of law and the legal system; the study of legal reasoning through the use of the case method. Required first course in the Law and Legal Institutions minor program. Open only to freshmen and sophomores except with the consent of the coordinator of the program.

201. Business Law (3) fall-spring
The law of contracts, agency, sales under the uniform commercial code and business organizations. A case and problems approach is used to develop analytic methods and research skills involved in the examination of numerous types of commercial transactions. Prerequisite: Eco 1, Acctg 51 or Acctg 108.

202. Business Law (3) spring
The law of negotiable instruments, secured transactions, real and personal property, corporations and partnerships. A case and problem approach is used. Prerequisites: Law 201, Fin 225.

221. (Phil 221) Sex-Discrimination and the Law (3)
A critical study of the law of sex-discrimination in areas of constitutional and labor law. A case approach which places emphasis on the rights of employees and the obligations of employers. Topics include equal protection, equal employment opportunity, and affirmative action. Lindgren

Law for Advanced Undergraduates

300. Apprentice Teaching in Law (1-3)

371. Directed Readings (1-3)
Readings in various fields of law, designed for students who have a special interest in a field of law.

Administration And Supervision

This department is one of three such organizations operating within the School of Education. Therefore, consult the School of Education entry in this section for a description of the academic program and descriptions of courses.

Aerospace Studies

Professor. Col. Lawrence Hasbrouck, U.S.A.F.; M.B.A., *chairman.*
Associate professors. Maj. Fred S. Deatherage, M.B.A.; Maj. Robert S. Kerico, M.S.B.A.; Maj. Robert J. Schafer, M.A.Ed.
Assistant professors. Capt. Stanley J. Jaworski, M.S.; Capt. Michael V. Sotak, M.A.

The Air Force Reserve Officers Training Corps (AFROTC) program at Lehigh was established in 1946. The program is conducted through the department of aerospace studies which offers two voluntary programs, one of four years and one of two years for students to qualify for a commission as a second lieutenant in the Air Force.

The general objective of the Air Force program is to instill in each student a basic understanding of associated professional knowledge, a strong sense of personal integrity and individual responsibility, an appreciation of the requirements of national security, and an opportunity to learn and develop leadership ability. The academic courses are available to all Lehigh students whether or not they want a commission.

Course credit. Advanced Aerospace Studies course credit may be substituted for six hours of electives for students in the College of Arts and Science and in the College of Business and Economics. In the College of Engineering and Physical Sciences, students taking the advanced ROTC courses may, with the approval of the adviser, take the "minimum" program in their curriculum and receive six hours credit.

Minor in Aerospace Studies

This program is designed to prepare an individual for commissioning as a second lieutenant in the U.S. Air Force and service as an Air Force officer upon graduation. It is a required program for any Lehigh student who plans to receive a commission in the Air Force through AFROTC. The minor recognizes two basic needs of Air Force officers: familiarization with mathematical concepts, and the officer as a manager and leader who can effectively communicate with others.

The minor in aerospace studies includes the following courses:

AS 21, 22	Freshman Aerospace Studies (2)
AS 23, 24	Sophomore Aerospace Studies (2)
AS 101	Field Training (0)
AS 113, 114	Air Force Management & Leadership (6)
AS 103	Flight Instruction (0)
AS 115, 116	National Security Force in Contemporary American Society (6)
Engl 1, 2	Composition and Literature (6)
Math 21	Analytic Geometry and Calculus (4)(3)
	credit hours 26 (25)

Notes: AS 103 is mandatory for, and available only to pilot candidates not already possessing a Federal Aviation Administration private pilot's license during their last year of aerospace studies.

English 10, 14 or 16 may replace English 2.

Math 31 (4 credit hours), Math 41 (3), or Math 388 (3) may replace Math 21. Other mathematical reasoning courses may be substituted with the approval of the department chairman.

A maximum of six credits in aerospace studies courses may be included in the credits required for graduation.

Advanced credit granted by Lehigh for any of the required courses listed above will be credited toward the minor. A minimum grade of C must be earned in each course for the student to be eligible for designation as a distinguished graduate. The department of aerospace studies monitors the minor.

Four-Year Program

The four-year program consists of classroom and laboratory work during the four undergraduate years and four weeks of field training, usually between the sophomore and junior years, at an airbase.

During the first two years the program acquaints students with aerospace history, the mission and organization of the Air Force, including technological advances and current research and development activities. Students also begin leadership training. During the last two years, emphasis is placed on personal development. Students practice leadership talents and abilities by assuming positions of responsibility in the Cadet Corps.

Two-Year Program

All requirements for commissioning can be completed in the two-year program. Students may apply for entry if they intend to complete two more full academic years either undergraduate, graduate, or a combination of both. Prior to formal enrollment, each student successfully completes six weeks of field training at an Air Force base.

Scholarship Program

Air Force ROTC awards scholarships at the freshman, sophomore and junior levels. They are available to qualified cadets in the two-year and four-year programs. Scholarships are given on a semester basis. The maximum is eight semesters (four years), the minimum four semesters (two years). Scholarships of seven, six and five semesters are also available.

The only requirement for scholarship eligibility is enrollment in the aerospace studies course. Commitment is not effective until acceptance of the scholarship or entrance into the advanced course. Once awarded a scholarship, a cadet continues on scholarship status until completion of the advanced course if all academic and military requirements are met. Scholarships cover full tuition, laboratory expenses, incidental fees, and books. Scholarship cadets also receive a $100 monthly tax-free subsistence allowance. More than half of the cadets enrolled have scholarship status.

Commissioning Requirements

To be eligible for the Air Force ROTC advanced program (final two years) and commissioning, a student must be a citizen of the United States, physically qualified for commission in the Air Force, not under fourteen years of age and, upon graduation, not more than thirty years of age. For those with prior military service commissioning must occur not later than age 35.

In addition, cadets must pursue work leading to at least a bachelor's degree and be willing to sign a formal agreement at the beginning of the advanced course or upon initiation of a college scholarship. The agreement, an enlistment into the Air Force Reserve, obligates the student to remain in the ROTC program, accept a commission and serve the required period in the Air Force upon graduation.

Aerospace Studies Courses

21. The Development of Air Power (1) fall
An examination of the developmental growth of air power from Revolutionary War days to the conclusion of World War II by reviewing the various concepts of employment and focusing upon the factors which prompted research and technological change.

22. The Development of Air Power (1) spring
A continuation of AS 21 from the conclusion of World War II to the present, with emphasis on a variety of events and elements in the history of air power, especially where these provide significant examples of the impact of air power on strategic thought.

23. The Air Force Today (1) fall
A study of the doctrine, mission and organization of the U.S. Air Force. A study of tactical and airlift forces, their mission, function, and employment.

24. The Air Force Today (1) spring
A study of U.S. strategic offensive and defensive forces, aerospace support forces, and a review of Army, Navy and Marines general-purpose forces.

101. Field Training (0) summer
In order to receive a commission through Air Force ROTC, a student attends field training, normally during the summer following the sophomore year. For students with credit for the first two years of aerospace studies, the training period is four weeks. All other students attend a six week period during which they complete the freshman and sophomore courses (AS 21 through 24). The academic portion of field training is taught by associate and assistant professors of aerospace studies. Both sessions include career and job orientation, organization and function of an Air Force base, junior officer training, physical training, small arms marksmanship, and survival. Travel pay is provided. Students receive approximately $100 per week in addition to room and board.

113. Air Force Management and Leadership (3) fall
AS 113 and 114 are integrated management courses, emphasizing the individual as a manager in an Air Force milieu. The individual motivational and behavioral processes, leadership, communication, and group dynamics are covered to provide a foundation for the development of the junior officer's professional skills. Organizational and personal values, management of forces in change, organizational power, politics, and managerial strategy and tactics are discussed. Actual Air Force cases are used.

114. Air Force Management and Leadership (3) spring
A continuation of AS 113.

Airborne Training Program (0) summer
Appropriate classroom, physical conditioning, and airborne parachute training (including five controlled parachute jumps) are available through a cooperative Air Force-Army program similar to that offered Air Force Academy cadets. Aerospace studies students volunteering for this course spend approximately three weeks at an active military installation during the summer preceding their final year in AFROTC. This is not required training.

102. Advanced Training Program (ATP) (0) summer
An honors program, highly recommended but not required to receive a commission. ATP is a two- or three-week orientation program on an Air Force installation, normally taken the summer prior to the final year by those with high academic standing. The program provides specialized career orientation and an opportunity to observe a working Air Force facility. The program provides contact with officers working in the student's specialty. Transportation, lodging and meals are provided in addition to approximately $100 per week.

103. Flight Instruction Program (FIP) (0) fall-spring
An introduction to powered flight taken during the final year in AFROTC for those students who are scheduled to enter Air Force pilot training after commissioning. Includes approximately fourteen hours of ground school covering principles of flight, flying and radio procedures, weather and navigation. Twenty-five hours of student flying include seventeen hours dual and eight solo. Successful completion requires a cross-country flight and passing an FAA flight evaluation. Students who complete the instruction and pass the FAA written examination and final flight check may receive an FAA private pilot's license. Prerequisites: AS 113, 114, acceptance into the Air Force ROTC program as a pilot candidate, and consent of chairman. Not open to those who hold an FAA private pilot's license.

115. National Security Forces in Contemporary American Society (3) fall
AS 115 and 116 conceptually focus on the armed forces as an integral element of society, with an emphasis on the broad range of American civil-military relations and the environmental context in which U.S. defense policy is formulated and implemented. Themes include: societal attitudes toward the military; the role of the professional military leader-manager in a democratic society; the fundamental values and socialization processes associated with the armed services; the requisites for maintaining adequate national security forces; political, economic, and social constraints on the national defense structure; the impact of technological and international developments on strategic preparedness; variables in national security policy, and military justice. In each semester, students prepare individual and group presentations for the class, write reports, and participate in group discussions, seminars and conferences.

116. National Security Forces in Contemporary American Society (3) spring
A continuation of AS 115.

Leadership Laboratory

Each cadet participates a minimum of one hour per week during every semester of enrollment. Leadership Laboratory is scheduled every Monday afternoon for the entire cadet corps.

The objective is to provide a laboratory environment in which each student receives an opportunity to learn and develop leadership and management abilities. Cadets plan, organize, and carry out the cadet group program with minimal guidance from the staff.

Cadets are promoted to cadet officer grades in the corps commensurate with their knowledge, experience, and demonstrated performance. Periodically, they move up the chain of command into positions of greater responsibility.

Advanced Degree Program. Certain students who meet high academic standards and are accepted at an accredited graduate school can delay their entrance into the Air Force until their advanced degree is obtained. In some instances the Air Force will defray the cost of this education.

American Studies

American Studies Committee. William G. Shade, Ph.D., professor of history and *director of American Studies*; James R. Frakes, Ph.D., Edmund W. Fairchild professor of American Studies; Joseph A. Dowling, Ph.D., distinguished professor of history; Peter G. Beidler, Ph.D., Lucy G. Moses distinguished professor of English; Lawrence H. Leder, Ph.D., professor of history; Edward J. Gallagher, Ph.D., associate professor of English; James R. McIntosh, Ph.D., associate professor of social relations; Howard R. Whitcomb, Ph.D., associate professor of government; Gary M. Burnley, M.F.A., assistant professor of fine arts; and Alice L. Eckardt, M.A., assistant professor of religion studies.

American Studies is an interdepartmental major emphasizing the idea that the institutions and values of a society comprise a whole, not merely the sum of its parts. By concentrating on the unique expressions of individuals contained in both the arts and popular culture and by studying the historical movements and contemporary institutions within which these expressions develop, American Studies reveals relationships which may not be clearly seen within the framework of a single discipline.

The broad interdisciplinary nature of American Studies equips the student with a well-rounded general education and a wide range of career opportunities. The student may choose to emphasize American history or literature to provide an excellent preparation for graduate school in these areas as well as in American Studies. In addition the major can be combined with other majors, such as journalism, or minors, such as business or Law and Legal Institutions, to furnish a sound underpinning for careers in those areas. With suitable collateral courses, the major also can prepare students for advanced work in museum administration, library science, social work and for teaching in both secondary schools and community colleges.

The major consists of fifteen hours of preliminary courses dealing with American literature, history and popular culture. All students in any major program are also required to take two American Studies courses, one at the intermediate level introducing the general approach of the major and a senior seminar on contemporary American civilization. In connection with the director of American Studies, who serves as the adviser for the major, each student chooses a program of fifteen semester hours of upper-level courses drawn from four different groups of courses and six hours of cognate courses relating American civilization to aspects of Western civilization generally. The major requirements total 42 credit hours.

Required preliminary courses (15 credit hours)

Hist 9	Formation of American Society (3)
Hist 10	American Society in the Industrial Era (3)
Engl 23	American Literature I (3)
Engl 24	American Literature II (3)

three credit hours in the area of American Popular Culture chosen from:

Art 16	Media (3)
SR 53/55/57	Popular Culture (1-3)
Engl 63	Narrative Cinema (3)
Engl 83	Popular Literature (1-3)
Engl 89	Science Fiction (3)

Required American Studies courses (6)

Intermediate level: The American Character (3)
Senior seminar: Themes in Contemporary American Civilization (3)

Required upper-level courses (15)

Choose six hours each from two of the following groups and three hours from a third group.

Literature

Engl 376	Early American Literature (3)
Engl 377	American Romanticism (3)
Engl 378	American Realism (3)
Engl 379	Twentieth-Century American Literature (3)
Engl 380	Contemporary American Literature (3)
Engl 382	Themes in American Literature (3)

History

Religion Studies 53	Religion and the American Experience (3)
Hist 119	Colonial America (3)
Hist 120	Revolutionary America (3)
Hist 325	American Social History 1607-1877 (3)
Hist 326	American Social History Since 1877 (3)
Hist 327	American Intellectual History (3)
Hist 328	American Intellectual History (3)

Government and Society

Gov 317	American Presidency (3)
Gov 327	Socialization and the Political System (3)
Gov 351	Constitutional Law (3)
Gov 352	Civil Rights (3)
Urban Studies 321	White Protestant America (3)
Soc 141	Social Deviance (3)
Soc 364	The Family (3)
Soc 370	Juvenile Delinquency (3)

Minorities in America

Urban Studies 125	American Ethnic Groups (3)
Urban Studies 328	American Jewish Community (3)
Engl 311	Literature of Women (3)
Engl 312	Jewish Literature (3)
Engl 316	Indian in American Literature (3)
Engl 319	Black in American Literature (3)
Hist 331	Negro in America (3)
Hist 324	Women in American History (3)
Anthropology 182	Aboriginal Cultures of North America (3)

The courses listed here are recommended, but comparable courses in each of these areas may be substituted with written permission of the director of American Studies.

Required cognate courses (6)

Choose six hours from the following:

Engl 385	Twentieth-Century World Literature (3)
Engl 386	Contemporary World Literature (3)
Arch 209	History of Architecture (3)
Arch 210	History of Architecture (3)
Art 220	Twentieth-Century Art (3)
Gov 101	Classical Political Heritage (3)
Gov 102	Modern Political Heritage (3)
Hist 355	European Intellectual History (3)
Hist 356	European Intellectual History (3)
HPT 113	Science and Human Values
Phil 150	Media and Values

Admission to honors in American Studies is by invitation of the committee in the student's junior year. The student must attain an average of 3.2 in major courses in addition to the university honors requirements.

Art and Architecture

Professor. Richard J. Redd, M.F.A.
Associate professors. Carlos J. Alvare, M.Arch, M.C.P.; Ricardo Viera, M.F.A., director of exhibitions and collection.
Assistant professors. Nicholas Adams, Ph.D., *chairman*; Gary Burnley, M.F.A.

The department of art and architecture offers three major programs designed to introduce the student to the fine arts, their history and techniques.

A major in studio art introduces the student to the basic media of art such as drawing, printmaking, painting and photography. The major is designed to encourage the student to develop the skills which allow creative expression in the visual arts.

The art history major offers a basic foundation in Western art and architectural history. Advanced courses are available at Muhlenberg and Lafayette colleges through the Lehigh Valley Association of Independent Colleges. An art history major prepares the student for graduate study. It is advised that the major who plans to continue at the graduate level study German.

The architecture major introduces the student to the problems of the built environment. Design is of primary concern for this major but the history of architecture and a strong social science emphasis are also encouraged. Internships are available in local government through the Urban Observatory and the department. The major leads to a liberal arts bachelor of arts degree and it is expected that students will go on to an architectural school accredited by the American Institute of Architects.

In addition to the above three major programs, individually structured programs may be planned, such as studio art with an emphasis on architectural design, art history with an emphasis on museum training, architecture with an emphasis on planning or urban studies. Majors with psychology are possible for students who seek a career in art history. A major in art and a minor in education are available for students who contemplate becoming general elementary school teachers.

The department also offers minors in each of its programs. Engineering students take five courses in architecture for a General Studies minor. A double degree, bachelor of science and bachelor of arts, is available in five years for students from engineering who choose to major in architecture. Studio or art history minors may be established by taking five courses in either program.

The resources of the Lehigh University art collection, art exhibitions, field trips and contact with area architects and planners extend the programs of art and architecture into campus and community. Several major museums within easy traveling distance facilitate the first-hand study of art. Students of art history may do research on the university collection.

Cooperation with nearby Moravian College allows students to register for art courses not offered at Lehigh such as ceramics, sculpture and design graphics.

Certain studio courses with limited space, i.e., Art 10, 11, 12, 20, 23 and 161 are restricted in enrollment. For these courses, students should register with the department.

Studio Art Major

Forty-two credit hours are required.

Required preliminary courses (15 credit hours)

Art 5	Introduction to the Visual Arts (3)	
Art 11	Basic Drawing (3)	
Art 12	Three-Dimensional Design (3)	
Art 10	Design (3)	*or*
Art 20	Color (3)	
Art 16	Media (3)	

Required art history courses (9 credit hours)

Art 1	Introduction to Art History I (3)
Art 2	Introduction to Art History II (3)

plus one of the following:

Art 220	20th Century Art (3)
Art 222	Seminar in Contemporary Art (3)
Art 223	Seminar on a Modern Master (3)

Required major courses (18 credit hours)
Art Studio: six courses, two at the advanced level. The department maintains a file of courses in related areas that are recommended for majors in studio art.

Architecture Major

Fifty-nine credit hours are required.

required preliminary courses (20 credit hours)

Art 5	Introduction to the Visual Arts (3)
Arch 43	Introduction to Architectural Design (4)
Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry and Calculus II (4)
Phys 11	Introductory Physics I (4)
Phys 12	Introductory Physics Lab I (1)

required major courses (18 credit hours)

Arch 3	History of Architecture I (3)
Arch 4	History of Architecture II (3)
Arch 143	Intermediate Architectural Design I (3)
Arch 144	Intermediate Architectural Design II (3)
Arch 145	Architectural Structures (not open to students who have completed Mech I and Mech II) (3)
Arch 244	Advanced Architectural Design (3)

one of the following (three credit hours)

Art 11	Basic Drawing (3)
Art 23	Life Drawing (3)

six of the following (18 credit hours)

Arch 151	History of Urban Design (3)
Arch 152	Physical Planning and Design (3)
Arch 207	Renaissance Architecture (3)
Arch 209	Architecture 1750-1880 (3)
Arch 210	20th-Century Architecture (3)
Arch 342	Architectural Theory (3)
U.S. 363	Philadelphia (3)
Gov 328	The Politics of Urban Policy (3)

Study of a foreign language, preferably French, is strongly recommended.

Art History Major

Forty-two credit hours are required.

Required preliminary courses (9 credit hours)

Art 1	Introduction to Art History I (3) and
Art 2	Introduction to Art History II (3) *or*
Arch 3	History of Architecture I (3) and
Arch 4	History of Architecture II (3)
and Art 5	Introduction to the Visual Arts (3)

one of the following (three credit hours)

Art 10	Design (3)
Art 11	Basic Drawing (3)
Art 23	Life Drawing (3)
Arch 43	Introduction to Architectural Design (4)

one of the following (three credit hours)

Clss 201	Archaeology of the Near-East (3)
Clss 202	Archaeology of Greece (3)
Clss 203	Archaeology of Italy (3)

nine of the following (27 credit hours)

Art 115	Italian Renaissance Art (3)
Arch 151	History of Urban Design (3)
Art 175	Research, Collection and Historical Preservation (3)
Arch 207	Renaissance Architecture (3)
Arch 209	19th Century Architecture (3)
Arch 210	20th Century Architecture (3)
Art 219	19th Century Painting (3)
Art 220	20th Century Art (3)
Art 222	Seminar in Contemporary Art (3)
Art 223	Seminar in a Modern Master (3)
Arch 342	Architectural Theory (3)
Art 26	Medieval Art (Muhlenberg) or Art 22 (Lafayette)
Art 36	Baroque Painting (Lafayette)
Art 42	Painting in Northern Europe (Muhlenberg) *or* Art 32 (Lafayette)

Undergraduate Courses in Art and Architecture

1. Introduction to Art History I (3) P fall, alternate years
Development of painting and sculpture primarily in the Western tradition from paleolithic to modern times. Redd

2. Introduction to Art History II (3) P spring, alternate years
Painting and sculpture primarily of Western civilization from the 16th century to modern times. Redd

3. History of Architecture I (3) P fall, alternate years
Architecture from prehistoric times to the Romanesque. Evolution of design, influence of technical achievements, relation to society and culture. Adams

4. History of Architecture II (3) P spring, alternate years
Architecture from the Gothic period to the present. Evolution of design, impact of industrialization, growth of the architectural profession. Adams

5. Introduction to the Visual Arts (3) P fall
Principles of visual expression. Examples of art from various periods are examined in relation to their historical and cultural context, to their plastic organization and their significance as reflection of human experience. Redd, Burnley

10. Design (3) UP fall, alternate years
Design and composition in two dimensions. Basic color theory. Individual and group projects directed towards developing visual awareness. Redd

11. Basic Drawing (3) UP fall
Concepts and practice of building and representing three-dimensional form. Methods and media of drawing. Burnley

12. Three-Dimensional Design (3) UP spring
Individual and group projects directed toward developing design in three dimensions. Exploration of materials and their application. Burnley

16. Media (3) UP spring
Readings, discussions and workshops investigating the power and potential of vision in shaping contemporary life. Individual and group projects explore the effects of visual information (TV, magazines, advertising, architecture, etc.) in the 20th century. Prerequisite: consent of the department chairman. Burnley

20. Color (3) UP fall, alternate years
Projects directed toward building an awareness of color. Study and observation of the dynamics of color in theory and practice. Redd

23. Life Drawing (3) UP spring
Drawing from the live model as the fundamental experience towards building form. Burnley

33. Painting (3) fall-spring
Painting in oil, acrylic or watercolor oriented toward developing individual creative expression combined with an understanding

of the physical nature of the materials. Studio prerequisite: Art 10, 11 or 20 or consent of the department chairman. Redd, Burnley

37. Introduction to Printmaking (3) fall
A structured course in mono print, relief "block" printing and basic etching. Introducing materials and tools, stressing creative application and the conceptual aspects of the media. Prerequisite: Art 11. Viera

38. Lithography and Intaglio (3)
History and Principles of lithography (stone and aluminum plate) and intaglio printmaking (etching, aquatint, drypoint). Prerequisite: Art 11. Viera

43. Introduction to Architectural Design (4)
Basic architectural design. Function, selection and organization of spaces. Study of light, color and texture. Emphasis on creative concepts in relation to the built environment. Includes laboratory section in architectural drawing. Critiques and juries. Alvare

115. Italian Renaissance Art (3) UP fall, alternate years
Painting, sculpture and architecture in Italy from the 14th to the 16th century; the legacy of medieval thought, the developing interest in nature, the new relation to the classical tradition. Emphasis on Masaccio, Donatello, Raphael and Michelangelo. Adams

123. Advanced Life Drawing (3) spring
Advanced drawing from the live model. Prerequisite: Art 23. May be repeated for credit. Burnley

133. Intermediate Painting (3) fall-spring
Problems in oil, watercolor, acrylic and mixed media. Prerequisite: Art 33. Redd, Burnley

143. Intermediate Architectural Design I (3) fall-spring
Concentrated projects in architectural design. Individual and team planning. Emphasis on actual problems of architectural form and expression in contemporary society. Conferences, critiques and juries. Prerequisite: Arch 43 or consent of the department chairman.

144. Intermediate Architectural Design II (3) fall-spring
More advanced study in architectural design and site planning. Increase in scope and complexity of projects. Critiques and juries. Prerequisite: Arch 143 or consent of the department chairman.

145. Architectural Structures (3) fall
Structural forms and systems; methods and techniques of structural analysis. Terminology, formulae, problems in structure. Prerequisite: Math 21 and 22. Not open to students who have completed Mech 1 and Mech 11.

151. History of Urban Design (3) fall
Historical development of urban design in the evolution of the city. Theories of city planning. Special emphasis is given to the social and economic parameters which determine physical design. Methods and practices used in the United States today. Seminar course. Prerequisite: Arch 43 or consent of the chairman.
Alvare

152. Physical Planning and Design (3) spring
Solution of a physical planning problem with special emphasis on the relationship between the design functions and the social, economic and political programs under which the plan will develop. Studio course. Prerequisite: Arch 151. Alvare

161. Introduction to Photography (3)
Making and viewing of photographs. Basic camera and darkroom techniques, mechanics and materials. Class discussion and assignments in photographic history. Individual and group projects. Instruction directed toward development and use of photography as an art medium. Lab fee required.

175. Research, Collection and Historical Preservation (3) fall
Introduction to the methods and procedures of research on art objects, historical sites, and documents. The nature of museum work in its practical aspects. Field trips and workshops. Each student completes a research report or equivalent. Prerequisite: consent of the department chairman. Viera

207. Renaissance Architecture (3) fall, alternate years
History of architecture and urban form during the Italian Renaissance. Major architects (Brunelleschi to Palladio) building types (church, palace and fortress) and urban centers (Pienza, Rome and Venice). Adams

209. Architecture 1750-1880 (3) fall, alternate years
From the industrial revolution to the skyscraper. The nature of industrial architecture and its effect on cities and city planning. Emphasis on France, England, Germany and America. Adams

210. 20th Century Architecture (3) spring
History and theory of architecture from 1880. Emphasis on F.L. Wright, Le Corbusier, and Mies van der Rohe and the problems of contemporary design. Adams

211. Advanced Drawing (3) fall-spring
Projects in creative drawing designed to build on concepts and practices initiated in basic drawing and life drawing. May be repeated for credit. Prerequisites: Art 11 and 23. Burnley

219. 19th-Century Painting (3) fall, alternate years
From Neoclassicism through the sequential movements of Romanticism, Naturalism, Impressionism, and Post-Impressionism in art of Europe and the U.S. Redd

220. 20th-Century Art (3) spring
Sequential movements in contemporary painting and sculpture. Their interrelations as cultural expression. Museum reports and critical interpretation. Redd

222. Seminar in Contemporary Art (3) fall, alternate years
Recent aspects, developments in contemporary art. Exploring ideas and consequences of today's image-making. Studio workshops, readings, discussions and museum visits. Prerequisite: Art 2 or 5. Burnley, Viera

223. Seminar on a Modern Master (3) fall, alternate years
An in-depth study on one artist in all aspects of his creative development. Such artists as Picasso, Klee, Matisse and Henry Moore will be covered in turn. Redd

233. Advanced Painting (3) fall-spring
Provides creative work in depth in a variety of painting media. Prerequisite: Art 133 or consent of the department chairman. May be repeated for credit. Redd, Burnley

237. Intermediate Printmaking (3) fall-spring
Aluminum plate lithography and basic serigraphy. Further exploration in relief and intaglio printing. Survey of special topics, reading in the history of printmaking, problems in edition printing and today's print market. Prerequisite: Art 37 or 38. Viera

244. Advanced Architectural Design (1-3) fall-spring
Individual study, project or other assignment for advanced students or majors capable of progress beyond general course content or requirement. Conferences and critiques. May be repeated for credit. Prerequisite: Arch 144 and consent of the department chairman. Alvare

261. Photography Workshop (3) fall-spring
Projects and techniques for the more advanced student. Individual and group assignments. Prerequisite: Art 161 and consent of the department chairman.

269. Special Topics in Art History (3) fall-spring
Directed projects for advanced students in the history of art or architecture. Prerequisite: consent of the department chairman.

271. Special Topics in Architecture (3) fall-spring
Directed projects for advanced students in architecture or architectural criticism. Prerequisite: consent of the chairman.

273. Special Topics in Studio Practice (1-4) fall-spring
Individually directed projects for advanced students capable of undertaking independent creative work in applied art and photography. Prerequisite: consent of the department chairman.

275. Research and Museology (1-3)
Research and reading on art objects in the Lehigh art collection.

Curatorial problems in attribution, display, cataloging and conservation. Each student completes a research report or equivalent. May be repeated for credit. Viera

333. **Media in Painting** (3) spring
A painting course which focuses on historical techniques. Studio practice preparing and working in 15th- and 16th-century media. Reading on media and materials. Prerequisite: consent of the department chairman. Redd

337. **Printmaking Workshop** (3) fall-spring
Independent experimentation and work in a chosen graphic media for the advanced student. Photographic applications, conceptual problems and mixed media. Conferences and critiques. May be repeated for credit. Prerequisite: Art 237 or consent of the department chairman. Viera

342. **Architectural Theory** (3) spring, alternate years
Philosophy of significant architectural writers and theorists from Pugin to Venturi. Prerequisite: Arch 210. Adams

375. **Internship** (3) fall-spring
Internship under professional supervision in the principal museum areas: curatorship, conservation, exhibition, interpretation, and administration at the Lehigh University Exhibitions and Collection, Historic Bethlehem, Inc., and Lehigh County Historical Society. Prerequisites: Art 175, 275 and consent of the department chairman. Viera

Arts and Science

11. **Sex Roles and Society: Continuity and Change** (3) P
Interdisciplinary study of sex roles—their existing character and impact upon individuals and institutions: masculine and feminine social roles in fiction; historical attitudes toward marriage and men's and women's work; research on sex differences; ideals of sex equality.

Arts-Engineering

G. Mark Ellis, Ph.D. associate dean, College of Arts and Science, *curriculum director.*

The standard major for arts-engineers working towards a bachelor of science degree is applied science. This includes all of the science and engineering courses required in the freshman year and included in the pattern roster for the chosen field of engineering.

Arts-engineers with special interests outside engineering frequently combine another arts or science major with their engineering program. Interested students should consult with the curriculum director.

Recommended freshman year
Arts-engineering freshmen have the same roster of courses as do engineering freshmen, with the exception that the arts-engineering freshman takes Economics 1 the second semester in place of an elective. Refer to the recommended freshman year, College of Engineering and Physical Sciences.

Recommended professional sequences
Beginning with the sophomore year, the arts-engineering student will be guided by the appropriate pattern roster in the chosen field. The pattern roster shows the most effective way of combining arts and engineering courses to prepare for the last year in the branch of engineering chosen.

Although the minimum number of credit hours needed for the bachelor of arts degree is 120, a student in arts-engineering should expect to earn more than this in order to qualify for the bachelor of science degree in the chosen field of engineering at the end of the fifth year. The number needed for both degrees is shown for each pattern roster.

Arts-Chemical Engineering

A total of 155 credit hours are needed for the bachelor of arts and bachelor of science degrees.

sophomore year, first semester (16 credit hours)

Math 23	Analytical Geometry and Calculus III (4)
Chem 31	Equilibria (3)
ChE 41	Cascade Processing Concepts (3)
	distribution electives (6)

sophomore year, second semester (15 credit hours)

Math 205	Linear Methods (3)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
ChE 52	Introduction to Transport Phenomena (4)
Chem 187	Thermodynamics (3)

junior year, first semester (16 credit hours)

Chem 51	Organic Chemistry (3)
Chem 53	Organic Chemistry Lab (1)
Chem 191	Physical Chemistry (3)
ChE 167	Unit Operations (3)
	distribution electives (6)

junior year, second semester (14 credit hours)

Chem 192	Physical Chemistry Lab (2)
ChE 286	Modeling Simulation and Control (3)
	distribution electives (9)

senior year, first semester (15 credit hours)

	electives for engineering major (6)
	distribution electives (6)
	elective (3)

senior year, second semester (14 credit hours)

ChE 169	Unit Operations Lab (1)
ChE 210	Chemical Engineering Thermodynamics (4)
	elective for engineering major (3)
	distribution electives (6)

summer

ChE 100	Industrial Employment

Note: For senior-year engineering electives, the student should consult with the department of chemical engineering advisers.

Arts-Civil Engineering

A total of 159 credit hours are needed for the bachelor of arts and bachelor of science degrees.

sophomore year, first semester (15 credit hours)

Math 23	Analytical Geometry and Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
	distribution electives (6)

sophomore year, second semester (15 credit hours)

Math	Approved Mathematics Elective (3)
Mech 1	Statics (3)
	distribution electives (6)
	elective (3)

junior year, first semester (15 credit hours)

Mech 11	Mechanics of Materials (3)
CE 9	Civil Engineering Computations (1)
CE 11	Engineering Graphics (2)
	distribution electives (9)

junior year, second semester (15 credit hours)

Met 92	Structure and Properties of Materials (3)
CE 40	Principles of Surveying (3)
	distribution electives (9)

summer CE 41 Engineering Surveys (3)

senior year, first semester (17 credit hours)

CE 109	Numerical Techniques (2)
CE 121	Mechanics of Fluids (3)
CE 143	Soil Mechanics (3)
CE 159	Structural Analysis (3)
	electives (6)*

senior year, second semester (15 credit hours)

Mech 104	Dynamics and Vibrations (3)
CE 160	Structural Design (3)
CE 170	Environmental Engineering (3)
CE 222	Hydraulic Engineering (3)
	elective (3)*

summer CE 100 Summer Employment
Eight weeks of summer employment should precede fifth year. Consult the department chairman.
*Electives which require approval of the civil engineering department.

Arts-Computer Engineering

A total of 157 credit hours are needed for the bachelor of arts and bachelor of science degrees.

sophomore year, first semester (15 credit hours)

Math 23	Analytical Geometry and Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
	distribution electives (6)

sophomore year, second semester (15 credit hours)

EE 141	Switching Theory and Logic Design (3)
Math 205	Linear Methods (3)
	distribution electives (3)
	electives (6)

junior year, first semester (16 credit hours)

EE 11	Principles of Computing Techniques (4)
Math 231	Statistical Inference or
Math 309	Theory of Probability (3)
	distribution electives (9)

junior year, second semester (16 credit hours)

EE 20	Introduction to Circuit Theory (4)
EE 201	Computer Architecture (3)
	distribution electives (9)

senior year, first semester (14 credit hours)

EE 105	Electronic Circuits (4)
EE 104	Linear Systems and Signals (4)
	approved elective (3)*
	distribution elective (3)

senior year, second semester (14 credit hours)

EE 315	Principles of Computer Software (3)
EE 317	Analytical Methods for Information Sciences (3)
EE 142	Junior Lab (2)
	approved elective (3)*
	elective (3)

summer EE 100 Industrial Employment
*Electives which require approval of the department of electrical engineering.

Arts-Electrical Engineering

A total of 157 credit hours are needed for the bachelor of arts and bachelor of science degrees.

sophomore year, first semester (15 credit hours)

Math 23	Analytical Geometry and Calculus III (4)
Phys 21	Introductory Physics (4)
Phys 22	Introductory Physics Lab II (1)
	distribution electives (6)

sophomore year, second semester (16 credit hours)

Math 205	Linear Methods (3)
Mech 103	Principles of Mechanics (4)
	distribution elective (3)
	electives (6)

junior year, first semester (16 credit hours)

EE 11	Principles of Computing Techniques (4)
Math 231	Statistical Inference *or*
Math 309	Theory of Probability (3)
	distribution electives (9)

junior year, second semester (16 credit hours).

EE 20	Introduction to Circuit Theory (4)
	science elective (3)†
	distribution electives (9)

†Note: At least one subject must be in physics, chemistry or biology. Quantum mechanics is the best choice for those planning a program in electronics.

senior year, first semester (14 credit hours)

EE 105	Electronic Circuits (4)
EE 104	Linear Systems and Signals (4)
	approved elective (3)*
	distribution elective (3)

senior year, second semester (14 credit hours)

EE 103	Physical Electronics (3)
EE 236	Electromagnetic Fields I (3)
EE 106	Electromechanics and Machines (3)
EE 142	Junior Lab (2)
	approved elective (3)*

summer EE 100 Industrial Employment
*Electives which require approval of the department of electrical engineering.
Note: Students must choose at least one approved elective in mathematics and at least one approved elective in materials, thermodynamics, fluid mechanics, or physical chemistry by the end of the above-mentioned senior year, second semester.

Arts-Engineering Physics

A total of 158 credit hours are needed for the bachelor of arts and bachelor of science degrees.
Arts-engineering physics students complete, during the first four years, the physics major under the guidance of the chairman of the department of physics.

Arts-Industrial Engineering

A total of 161 credit hours are needed for the bachelor of arts and bachelor of science degrees.

sophomore year, first semester (16 credit hours)

Math 23	Analytical Geometry and Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
IE 7	Deterministic Models (4)
	distribution elective (3)

sophomore year, second semester (15 credit hours)

IE 110	Engineering Probability (3)
IE 18	Data Processing Fundamentals (3)
	engineering science elective (3)*
	distribution electives (6)

junior year, first semester (15 credit hours)

Math 205	Linear Methods (3)

IE 205 Engineering Statistics (3)
engineering science elective (3)*
distribution electives (6)

junior year, second semester (16 credit hours)

IE 206 Operation Research Techniques (4)
engineering science elective (3)*
distribution electives (6)
elective (3)

senior year, first semester (16 credit hours)

IE 101 Fundamentals of Manufacturing Engineering (4)
engineering science elective (3)*
distribution electives (9)

senior year, second semester (16 credit hours)

IE 104 Work Systems (4)
engineering science electives (6)*
electives (6)

summer

IE 100 Industrial employment should precede the fifth year. Consult the chairman of the department of industrial engineering.

*Note: Engineering science electives must be approved by the department of industrial engineering adviser.

Arts-Mechanical Engineering and Mechanics

A total of 158 credit hours are needed for the bachelor of arts and bachelor of science degrees.

sophomore year, first semester (17 credit hours)

Phys 21 Introductory Physics II (4)
Phys 22 Introductory Physics Lab II (1)
Math 23 Analytical Geometry and Calculus III (4)
ME 12 Engineering Drawing and Descriptive Geometry (2)
distribution electives (6)

sophomore year, second semester (15 credits)

Mech 1 Statics (3)
Math 205 Linear Methods (3)
ME 104 Thermodynamics (3)
distribution elective (3)
elective (3)

junior year, first semester (15 credit hours)

Met 63 Engineering Materials and Processes (3) or
Met 91 Elements of Materials Science (3)
Mech 11 Mechanics of Materials (3)
distribution electives (9)

junior year, second semester (15 credit hours)

Mech 102 Dynamics (3)
ME 21 Mechanics Engineering Laboratory I (1)
ME 231 Fluid Mechanics (3)
EE 160 Electrical Circuits and Apparatus (4)
EE 162 Dynamo Laboratory (1)
elective (3)

senior year, first semester (15 credit hours)

ME 105 Thermodynamics II (3)
Math 208 Complex Variables or
Math 231 Statistical Inference (3)
Mech 203 Advanced Strength of Materials (3)
distribution electives (6)

senior year, second semester (17 credit hours)

ME 101 Mechanical Engineering Design (1)
ME 151 Mechanical Elements (3)
ME 242 Mechanical Vibrations (3)
CE 123 Fluid Mechanics Laboratory (1)
distribution electives (6)
elective (3)

Arts-Metallurgy and Materials Engineering

A total of 162 to 164 credit hours are needed for the bachelor of arts and bachelor of science degrees, depending on the option selected.

sophomore year, first semester (16 credit hours)

Met 63 Engineering Materials and Processes *or*
Met 91 Elements of Materials Science (3)
Math 23 Analytical Geometry and Calculus III (4)
Phys 21 Introductory Physics II (4)
Phys 22 Introductory Physics Lab II (1)
Met 10 Metallurgical Laboratory (1)
distribution elective (3)

sophomore year, second semester (15-16 credit hours)

Mech 1 Statics (3)
EE 160 Electrical Circuits and Apparatus *or*
Phys 31 Introduction to Quantum Mechanics (3-4)
Math 205 Linear Methods (3) *or*
Math 231 Statistical Inference (3)
distribution electives (6)

junior year, first semester (15 credit hours)

Met 207 Electron and Crystal Structure (3)
Met 210 Metallurgical Thermodynamics (3)
Mech 11 Mechanics of Materials (3)
ChE 60 Engineering in Chemical Manufacturing (3)
distribution elective (3)

junior year, second semester (15 credit hours)

Met 208 Phase Diagram and Transformations (3)
Met 218 Mechanical Behavior of Materials (3)
distribution electives (9)

senior year, first semester (15 credit hours)

Chem 207 Metallic Elements (3)
Met 307 Structure and Behavior of Materials (3)
distribution electives (6)
elective (3)

senior year, second semester (16-17 credit hours)

ME 166 Procedures for Mechanical Design *or*
Mech 102 Dynamics (2-3)
Met 304 Extractive Metallurgy I (4)
Met 101 Professional Development (1)
distribution electives (6)
elective (3)

summer

Met 100 Industrial employment should precede the fifth year. Consult the chairman of the department.

Note: Students interested in the industrial or research option should consult with the department chairman prior to their fourth year. Students selecting the research option should elect Met 240, Research Techniques, in the second semester of the senior year.

Athletics and Recreation

Professor. William B. Leckonby, B.S., *director*
Associate professor. John S. Steckbeck, M.Sc.
Assistant professors. John N. Covert, B.S.; Gerald G. Leeman, B.A.; B. Thayer Turner, B.S.
Instructors. N. Craig Anderson, M.S., *business manager*; Barbara Lipkin, B.Sc.; J. Bruce Gardiner, M.Sc.; Brian Hill, B.A.; John L. Luckhart, M.Sc.; Charles R. McNaron, B.S.; Stanley R. Schultz, B.A.; Judith H. Turner, B.S.; John C. Whitehead, B.S.

The department of intercollegiate athletics and the department of recreation and intramural sports supervise the entire field of intercollegiate athletics, recreation and intramurals at the university. Activities consist of intercollegiate athletics, recreation, and intramural sports.

Facilities are afforded in Taylor Gymnasium, Grace Hall, Taylor Field, and Sayre Park Field, the latter an area of seven acres located above the Lookout on top of South Mountain and only a short distance from fraternity houses and residence halls. Saucon Valley Fields are located south of the campus. The 479 acres there accommodate the following facilities: all-weather quarter-mile track, nine all-weather tennis courts, lacrosse and soccer fields, three football practice fields, Varsity House, two baseball diamonds, twelve to sixteen intramural fields, and a football field. The area is the site of the Athletic and Convocation Center that will seat 6,000. Almost all outdoor intramural sports contests and all upperclass intramural activities are held on the Saucon fields; a shuttle bus service is provided.

The Saucon Valley athletic complex also features indoor squash courts. The Philip Rauch Field House includes an indoor track, and tennis, volleyball and basketball courts. A baseball diamond also has been completed.

Intercollegiate Athletics

The department offers the opportunity for undergraduate men and women to participate in intercollegiate competition both at home and away with institutions which are Lehigh's traditional rivals and also other institutions which are at some distance.

The intercollegiate program consists of varsity teams in football, cross country, soccer, wrestling, basketball, swimming, tennis, track, baseball, golf, lacrosse, hockey, squash, winter track, and rifle. In addition, there are junior varsity and/or freshman teams in some of the above.

The women's athletic program includes competition at the intercollegiate level with other colleges in field hockey, volleyball, basketball, swimming, tennis and lacrosse.

Intramural Sports and Recreation

The department supervises the intramural sports and the recreational physical activities of students. The aim is to insure the health and physical development of every student.

Through its program of intramural sports, the university endeavors to maintain among its students a high degree of physical fitness, to establish habits of regular and healthful exercise, to foster the development of such valuable byproducts as self-confidence, good sportsmanship, and a spirit of cooperation, and to provide each student with ample opportunity for acquiring an adequate degree of skill in sports of the type in which participation can be continued after graduation.

Prior to arrival on campus, each new or transfer student must submit to the Health Service a record of physical examination filled in and signed by a physician, and a completed health history form. All such forms are checked by the Health Service and each student is thereby classified for activities in accordance with current health status.

A wide variety of instruction courses are available on a voluntary basis. Courses stress the history, rules, fundamentals and playing situations of a sport. Instruction and competition for women students are available in a number of activities. Individual sports are offered on a voluntary basis.

In the gymnasium, opportunity is offered in the following activities: recreational swimming, beginner's swimming, dance, physical development, boxing, apparatus exercises, life-saving, controlled weight training, badminton, judo, karate, and sports fundamentals.

A comprehensive program in intramural sports is sponsored for the student body including fraternity, residence hall, interclass, town, and independent groups in touch football, tennis, soccer, badminton, handball, individual athletics, basketball, swimming, wrestling, track, softball, squash, volleyball, and recreative games. Students are encouraged to participate in these sports, and awards are given for excellence in performance.

The university maintains a well-equipped Health Service for medical treatment. If a student is injured while engaged in any sport he must report as soon as possible to the first-aid room or to the Health Service located in Johnson Hall.

All students in order to compete in intercollegiate activities must sign up for the student insurance program or have their own insurance program which covers athletic injuries.

Instructional Opportunities

The following programs and activities are open to all students: nonswimmers' program, basic swimming, senior life saving, water safety instruction, scuba diving (fee), fencing, bowling, golf, basic tennis, intermediate tennis, advanced tennis, modern dance, horsemanship (fee), physical fitness, personal defense (fee), stunts and tumbling, basketball, volleyball, softball, squash, handball, paddle ball, running, skating (fee), and skiing (fee).

No credit is given for these courses; they are voluntarily elected subject to permission of the instructor. A periodic announcement is made.

Biology

Professors. Saul B. Barber, Ph.D., *chairman*; Sidney S. Herman, Ph.D.; Richard G. Malsberger, Ph.D.
Associate professors. Steven Krawiec, Ph.D., (on leave 1978-79); Hayden N. Pritchard, Ph.D.
Assistant professors. Barry Bean, Ph.D.; David Bell, Ph.D.; Bruce R. Hargreaves, Ph.D.; David Cundall, Ph.D.; K. Elaine Hoagland, Ph.D.

The biology department offers students the bachelor of arts in biology and the bachelor of science in biology. The principal differences in requirements for the two majors are:

1. The bachelor of arts course of study requires the student to complete the distribution requirements of the College of Arts and Science in addition to the requirements of the biology major.

2. The bachelor of science course of study requires that, in addition to the requirements of the biology major, the student complete a total of thirty-one credit hours with a restriction on electives that they be outside the fields of natural science and mathematics.

3. The bachelor of arts curriculum has a total of sixty-two credit hours of courses in the major requirements as compared to eighty-three in the bachelor of science curriculum.

The bachelor of arts major in biology is not designed specifically for preprofessional training but it does exceed the minimum requirements for admission to medical, dental and allied professional colleges as well as to study for advanced degrees in most of the fields of graduate biology. It is, therefore, recommended to those students who desire good background in biology combined with the cultural background of the College of Arts and Science distribution requirements.

The bachelor of science major in biology is designed specifically for optimal scientific preparation for entry into professional graduate training in medicine, dentistry and allied professional

fields as well as in graduate biology. Such preprofessional training is obtained at the cost of a reduction in the number of nonscience courses a student will be able to take during a normal four-year undergraduate program. Students should, therefore, consider carefully before committing themselves to either program. An initial choice of one or the other program is revisable; this becomes more difficult after the freshman year.

Students also may apply for acceptance in either the six-year or seven-year B.A.-M.D. program offered in cooperation with two Philadelphia medical schools. The Lehigh University bachelor of arts requirements are completed and the M.D. requirements of one of the cooperating medical schools are also completed, both within a six-year or seven-year period. For details of both programs, consult the section on Health Professions, page 48.

Bachelor of Arts Major in Biology

required courses in biology

Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Laboratory (1)
Biol 28	Genetics (3)

plus six hours from each of the categories listed below; plus a three-hour elective chosen from any category. The selection of courses must include either Biol 331 or Biol 332.

Category I Organismic Biology

Biol 134	Comparative Vertebrate Anatomy (4)
Biol 303	Invertebrate Zoology (3)
Biol 313	General Histology (3)
Biol 314	Vertebrate Embryology (3)
Biol 322	Animal Physiology (3)
Biol 329	Herpetology (3)
Biol 331	Non-vascular Plants (3)
Biol 332	Evolution of Vascular Plants (3)
Biol 333	Symbiosis (3)

Category II Environmental Biology

Biol 306	Ecology (3)
Biol 309	Aquatic Biology (3)
Biol 317	Evolution (3)
Biol 324	Animal Behavior (3)
Biol 331	Nonvascular Plants (3)
Biol 333	Symbiosis (3)
Biol 361	Sanitary Microbiology (3)
Biol 319	Reproduction and Mating Systems (3)

Category III Cellular and Molecular Biology

Biol 135	Microbiology (3)
Biol 313	General Histology (3)
Biol 320	Cell Physiology (3)
Biol 322	Animal Physiology (3)
Biol 325	Advanced Genetics (3)
Biol 327	Cellular Regulation (3)
Biol 353	Virology (3)
Biol 371	Elements of Biochemistry I (3)
Biol 372	Elements of Biochemistry II (3)

Cognate courses in other departments (e.g., Psych 375, Physiological Psychology, Phys 367, Introduction to Molecular Biophysics, and Phys 368, Molecular Biophysics) will be assigned to a category by the major adviser. Biol 341, Biology of Marine Animals (6), satisfies three hours in Category I and three hours in Category II.

additional required courses

Math 41	BMSS Calculus (3)
Math 42	BMSS Probability (3)
Math 43	BMSS Linear Algebra (3) *or*
Math 44	Calculus (3)
Chem 21, 22	Chemical Principles & Laboratory (5)
Chem 51, 52, 55	Organic Chemistry & Laboratory (8)
Chem 39	Analytic Chemistry *or*
Chem 31	Chemical Equilibria in Aqueous Systems *or*
Chem 194	Physical Chemistry (3)
Phys 11, 12	Introductory Physics and Laboratory (5)
Phys 13, 14	General Physics and Physics Laboratory (4)

Recommended Sequence of Science Courses

freshman year

Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Laboratory (1)
Biol 28	Genetics (3)
Chem 21	Chemical Principles I (4)
Chem 22	Chemical Principles I Laboratory (1)
Math 41	BMSS Calculus (3)
Math 44	BMSS Calculus (3)

sophomore year

Chem 51, 52	Organic Chemistry (6)
Chem 55	Organic Chemistry Laboratory (2)
Math 42	BMSS Probability (3)
Biol	electives (3 or 6)

junior year

Phys 11, 12	Introductory Physics and Lab (5)
Phys 13, 14	General Physics and Lab (4)
Biol	electives (3, 6, or 9)

senior year one of the following:

Chem 39	Analytical Chemistry
Chem 31	Chemical Equilibria
Chem 194	Physical Chemistry (3)
Biol	electives (3, 6, or 9)

Bachelor of Science Major

required courses in biology

Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Lab (1)
Biol 28	Genetics (3)

plus nine hours from each of the three categories listed above. The selection of courses must include Biol 331 or Biol 332.

additional required courses

Math 21, 22, 23	Analytic Geometry and Calculus (12) *or*
Math 41, 42, 43, 44	BMSS Calculus, Probability and Linear Algebra (12)
Chem 21	Introductory Chemical Principles (4)
Chem 22	Chemical Principles Lab (1)
Chem 51, 52	Organic Chemistry (6)
Chem 55	Organic Chemistry Lab ²2)
Chem 31	Chemical Equilibria (3)
Chem 187 or 194	Physical Chemistry (3)
Phys 11	Introductory Physics I (4)
Phys 12	Introductory Physics Lab I (1)
Phys 13	General Physics (3)
Phys 14	General Physics Laboratory (1)
Geol 1	Principles of Geology (3)
elective	any course in the natural sciences or mathematics (3)

and one of the following:

Psych 1	Introduction to Psychology (3)
Psych 109	Statistical Analysis (3)
Phil 261	Philosophy of the Natural Sciences (3)

and 31 hours of non-science electives.

Recommended Sequence of Science Courses

freshman year

Biol 21, 22	Principles of Biology and Lab (4)
Biol 28	Genetics (3)
Math 21, 22	Analytical Geometry and Calculus I, II (8) *or*
Math 41, 44	BMSS Calculus (6)
Chem 21, 22	Chemical Principles I and Lab (5)

sophomore year

Chem 51, 52, 55	Organic Chemistry and Lab (8)
Math 23	Analytic Geometry and Calculus III (4) *or*
Math 42, 44	Probabiliiy and Calculus
Biol	electives (6)
Psych	elective (3) *or*
Phil	elective (3)

junior year

Geol 1	Principles of Geology (3)
Phys 11, 12	Introductory Physics I and Lab (5)
Phys 13, 14	General Physics and Lab (4)
Psych	elective (3) *or*
Phil	elective (3)
Biol	electives (6-12)

senior year

Chem 31	Chemical Equilibria (3)
Chem 187 or 194	Physical Chemistry (3)
Biol	electives (6-12)

Biology minor

A minor in biology may be achieved by completing the following requirements:

Biol 21, 22	Principles of Biology and Laboratory (4)
Biol	electives (12)
Chem 21, 22	Chemical Principles and Laboratory (5)
Chem 51	Organic Chemistry (3)
Phys 11, 12	Introductory Physics and Laboratory (5)
Math 41	BMSS Calculus (3)

total credits 32

Undergraduate Courses in Biology

1. Biology and Society (3)
Principles and implications of modern biological thought for non-science, business, and engineering majors. Areas of high social relevance, such as genetics, behavior, populations, and environment. May not be substituted for or taken in addition to Biol 21.

21. Principles of Biology (3) fall-spring
Introduction to biology by study of selected principles. Topics covered include cell structure and function, plant and animal structure and function, dimersity and evolution of organisms. Three lectures per week.

22. Introduction to Biology Laboratory (1) fall-spring
Laboratory observations and experiments to illustrate how biological information is acquired. Designed primarily as a laboratory to accompany Biol 21. Prerequisite: Biol 21 previously or concurrently. One three-hour laboratory per week. Graded only pass-fail.

28. Genetics (3) fall-spring
Organization, replication, and transmission of hereditary information. Mechanisms of expression and modification of genes.

134. Comparative Vertebrate Anatomy (4) fall
A course in vertebrate zoology with emphasis on the study of homologous body structures in the various vertebrate classes and their relationship to the functional demands of habit and environment in each class. Detailed dissections of representative vertebrates are made in the laboratory. Two lectures and two laboratory periods. Prerequisites: Biol 21 and 22, or equivalent; sophomore standing. Cundall

135. Microbiology (3) fall-spring
The appearance, physiology, and taxonomy of prokaryotes. Two lectures and one laboratory period. Prerequisite: Chem 52, previously or concurrently.

191. (Geol 191) Environmental Science Seminar (3)
Seminar on current problems and developments in environmental science. May be repeated for credit. Prerequisite: sophomore standing. Evenson, Bell

For Advanced Undergraduates and Graduate Students

221. Undergraduate Research (3)
Laboratory work, field work, or both, depending upon the interest and competence of the student. Prerequisites: junior standing and consent of the department chairman.

231. Natural History and Ecology (3) summer
A concentrated course in recognition of species of plants and animals and study of their interrelationships in natural and altered environments. Lectures and seminars in use of keys and preservation of collections. Designed for secondary school teachers in life sciences. Prerequisites: graduate standing or consent of the department chairman.

232. Natural History and Ecology Workshop (3)
Field and laboratory work in natural history and ecology. Must be taken concurrently with Biol 231.

241. Ecology of Wetlands (6) summer
Study of plants and animals of wetlands areas and their interrelationships with the environment. The importance of the wetlands to the marine environment and methods of conservation. Independent study will form part of the course. Primarily designed for secondary school teachers of the sciences. Prerequisite: consent of the department chairman. (Offered only at The Wetlands Institute.)

261. Special Topics in Biology (1-3)
Research, conferences, and reports on selected topics not covered in the general undergraduate offerings. May be taken more than once for credit. Prerequisite: consent of the department chairman.

262. Special Topics in Biology (1-3)
Continuation of Biol 261.

303. Invertebrate Zoology (3) spring
Detailed survey of representative invertebrates. Anatomical and histological examination of selected types. Concepts of evolution and speciation. Two lectures and one laboratory. Prerequisite: two semesters of biology, one with laboratory. Herman or Hoagland

306. Ecology (3) fall-spring
Basic principles and applications of ecological interrelationships. Examination of ecological phenomena at the individual, population, community, and ecosystem levels. Two lectures and one laboratory period or field trip. Prerequisite: two semesters of biology, one with laboratory. Herman or Hoagland

309. Aquatic Biology (3) alternate years
Lectures on the physical, chemical and biological aspects of the fresh-water environment including cyclic and seasonal changes. A consideration of the major groups of organisms and their interactions. Influence of manmade alterations including impoundments and waste disposal methods. Two lectures and one laboratory period or field trip. Prerequisites: Biol 21, 22 or equivalent. Bell

313. General Histology (3) fall-spring
The techniques of preservation and preparation of animal and plant tissues for microscopical study; comparative studies of fresh and preserved tissues. One lecture and two laboratory periods. Prerequisite: Biol 21 and 22 or equivalent; Biol 134 or equivalent recommended. Cundall

314. Vertebrate Embryology (3) spring
A study of reproduction from germ cell formation through establishment of the principal organ systems of the vertebrate body. Various mechanical and physiological problems confronting the growing embryo are considered, and direct observation of whole mounts, sections, and living material are made in the laboratory. Two lectures and one laboratory period. Prerequisite: Biol 134 or equivalent. Cundall

317. Evolution (3) spring
Mechanisms of evolution, emphasizing natural selection, genetic structure and variation of populations, and isolation. Origin of species and higher taxa. Rates of evolution, extinction. Prerequisite: Biol 28 and an additional semester of biology, or consent of the department chairman. Hoagland or Barber

319. Reproduction and Mating Systems (3)
Patterns of reproduction and sexuality in plants and animals with emphasis on natural selection and ecological principles. Topics include hermaphroditism, neoteny, larval forms, parental investment, complex life cycles, population structure. Lectures, discussions, readings from textbook, student reports. Prerequisites: Biol 28; Biol 306 or 317. Hoagland

320 Cell Physiology (3) fall
The fundamental processes of life at the cellular level, including permeability and related membrane phenomena, enzymatic transformations, respiration, photosynthesis, gene function, bioelectricity, and other aspects of neuron function, contractility and other kinds of protoplasmic motility. Two lectures and one laboratory. Prerequisites: two semesters of biology, at least one with laboratory; Chem 52 or consent of the department chairman. Barber or Hargreaves

322. Animal Physiology (3) spring
The physiology of organs and organ systems in animals. Emphasis on mammalian systems, but lower vertebrates and invertebrates are also included. Functions studied include digestion, nutrition, metabolism, excretion, respiration, circulation, locomotion, nervous and chemical coordination. Two lectures and one laboratory. Prerequisites: two semesters of biology, at least one with laboratory; Chem 52 or consent of the department chairman. Hargreaves or Barber

324. Animal Behavior (3) spring
Discussion of the behavior of invertebrates and vertebrates and analysis of the physiological mechanisms responsible for behavioral actions. Emphasis on perception, environmental stimuli, and adaptive value of specific behavior patterns. Prerequisite: Biol 21 or consent of the department chairman. Bell

325. Advanced Genetics (3) fall
Lectures and student contributions on selected aspects of genetics, with emphasis on the molecular approach. The structure, organization, and replication of genes. The expression of genetic information and its regulation in cellular and developmental biology. Prerequisite: Biol 28 or consent of the chairman. Bean

327. Cellular Regulation (3)
Systems of regulation of cellular activity and multicellular coordination: cell replication, movements and integration of activity within and between cells. Two lectures, one laboratory. Prerequisite: Biol 21 or 28. Bean

329. Herpetology (3)
Biology of amphibians and reptiles. Two lectures and one laboratory or field trip per week. Prerequisite: Biol 21 and consent of the department chairman. Open only to students who have not received credit for Biol 429. Cundall

331. Nonvascular Plants (3) fall
A comparative study of the ontogenetic and phylogenetic development of algae, fungi and bryophytes. The life cycles and ecological importance of representative organisms are examined. Two lectures and one laboratory. Prerequisite: Biol 21. Pritchard

332. Evolution of Vascular Plants (3) spring
A comparative study of the ontogenetic and phylogenetic development of vascular plants. The life cycles, ecological importance and cellular morphology of the higher plants are examined. Emphasis on the plants of Pennsylvania. Two lectures and one laboratory. Prerequisite: Biol 21. Pritchard

333. Symbiosis (3) fall
Consideration of factors governing symbiotic relationships, including phoresis, commensalism, parasitism, and mutualism. Lectures and demonstrations emphasizing the theoretical and applied aspects of morphological and physiological adaptation, nutrient assimilation and metabolism, development, host reactions, and the dynamics of host-symbiont interactions are presented. Laboratory experiments designed to acquaint the student with techniques, evaluation of data, and to demonstrate principles are carried out. Prerequisite: Biol 21. Two lectures and one laboratory. Cheng

341. Biology of Marine Animals (6) summer
Emphasis on comparative morphology and physiology of marine animals. Field trips for ecological observation and collection as well as anatomical study and physiological experimentation. Prerequisite: consent of the department chairman and two semesters of biology. (Offered only at The Wetlands Institute.)

353. Virology (3) spring
A lecture course on bacterial and animal viruses including taxonomy, physical and chemical properties, and the biochemical transformations of infected cells. Prerequisite: a course in microbiology or biochemistry. Malsberger

361. Sanitary Microbiology (3) spring
Laboratory, field work, and reports on the microbiology of water supplies, waste disposal, and food processing. Two lectures and one laboratory. Prerequisite: one semester of microbiology. Malsberger

371. (Chem 371) Elements of Biochemistry I (3) fall
A general study of carbohydrates, proteins, lipids, nucleic acids, and other biological substances and their importance in life processes. Protein and enzyme chemistry are emphasized. Prerequisite: one year of organic chemistry. Merkel or Schaffer

372. (Chem 372) Elements of Biochemistry II (3) spring
Dynamic aspects of biochemistry: enzyme reactions including energetics, kinetics, and mechanisms; metabolism of carbohydrates, lipids, proteins, and nucleic acids; photosynthesis, electron transport mechanisms, coupled reactions, phosphorylations, and the synthesis of biological macromolecules. Prerequisite: Chem 371. Merkel or Schaffer

Mini-Courses at The Wetlands Institute

The following courses, Biol 381 through 386, are one-credit mini-courses offered only at The Wetlands Institute. Approval of the department chairman is required for all of the courses.

381. Phytoplankton of Estuaries (1)
Survey of the phytoplankton found in New Jersey salt marsh waters. Laboratory work in collecting and identifying organisms, and lectures on the morphology, biochemistry, and physiology of the organisms.

382. Plant Succession in Salt Marshes (1)
Survey of the large plants found in salt marshes and in other marine environments. Field work collecting and identifying the plants; lectures on their biochemistry, physiology, and morphology.

383. Marine Invertebrate Zoology (1)
The dominant taxa of the marine environment: the wetlands fauna, including taxonomy, life history, adaptations, and interrelationships of these organisms. Consideration of the environmental parameters determining the distribution and abundance of marine fauna.

384. Estuarine Zooplankton (1)
Study of temporary and permanent members of the animal plankton of shallow water. Sampling techniques, life histories, and morphology of major forms. Lectures, laboratories and field trips.

385. Marine Habitats (1)
Ecological field course in the planktonic, benthic, marsh, and sand beach habitat of the coast of southern New Jersey. Emphasis on the major biotic associations in each area and their relationship to physical and chemical influences in the environment. Competition and predation in each habitat.

386. Marine Fish Taxonomy (1)
Lectures in anatomy and physiology of marine fishes. Laboratory will emphasize collecting procedures and identification of specimens.

Graduate Study in Biology

The biology department accepts a limited number of students who are interested in graduate study towards the doctor of philosophy degree. Candidates for the master of science degree are also accepted but emphasis is on the former degree. Currently the department averages about fifteen full-time graduate students in residence each year.

The training program initially emphasizes breadth in biology followed by concentration in a special field of interest. Because of the small size of the department staff and the restricted number of graduate students, staff and students work together closely, especially during the years of student specialization.

The first two or two-and-a-half years are devoted primarily to course work but some of these are special research and readings courses that may serve as starting points for thesis research. Staff members normally direct student research programs only in the areas encompassed by their own research interests. These are: comparative physiology of nerve and muscle, virology, biological oceanography, behavioral genetics, histochemistry, aquatic biology, biological aspects of water pollution, population ecology, and biology of nucleic acids. Interdisciplinary programs in biological aspects of marine sciences may also be arranged in cooperation with the Center for Marine and Environmental Studies.

Special department requirements for the master of science degree include one year of graduate bio-chemistry, one semester of graduate statistics and at least one semester of research, as well as passing a master of science qualifying examination. Requirements for the doctor of philosophy degree are determined by the student's special committee and are tailored to fit special needs and interests, but also include passing a special examination as well as a defense of the thesis.

The prerequisite for graduate work in biology is undergraduate training in biology, chemistry, physics and mathematics approximately equivalent to that taken by biology majors at Lehigh University. Minor deficiencies in these areas may be completed during the first year of graduate study, usually, however, without graduate credit. Candidates for admission to graduate study in biology should take the Graduate Record Examination Advanced Test in biology as well as the GRE Verbal and Mathematical Aptitude tests. Failure to include results of these examinations with application for admission can seriously delay or prevent action on the application.

Current projects in environmental and organismic biology include: cichlid ethology and visual physiology; salt marsh energetics and benthic macrofauna; marine commensalisms and behavioral bioassay; biology of suspension feeding; computer modeling of energetics; terrestrial vegetation ecology; population responses to water quality; comparative functional morphology ol the head in snakes and lizards; feeding behavior in snakes; snake systematics; zooplankton ecology; analysis of salt marsh food webs; evolution and ecology of reproductive patterns in invertebrates; ecology of host-parasite interactions; thermal pollution; and molluscan systematics and evolution.

Current projects in molecular and cell biology include: the behavior of microorganisms and its regulation; physical characterizations of mitochondrial DNA; physical and chemical characterizations of prokaryotic ribosomal RNAs; viral diseases of fishes; developmental plant biology; cytochemistry; estuarine phytoplankton; functional and ultrastructural analysis of invertebrate receptor systems.

An interdisciplinary doctor of philosophy program in molecular biology is offered by a committee of molecular biologists with members from the departments of biology, chemistry and physics. For details of the program, consult interdisciplinary graduate programs, section IV.

Graduate Courses in Biology

402. Comparative Animal Physiology (3)
Lectures and seminars on selected areas in the comparative physiology of animals. Introduction to the current literature of subjects studied. These include mechanisms of osmotic control, temperature effects, nerve and muscle physiology and others. Prerequisite: Biol 320 or 322. Barber

405. Special Topics in Biology (1-3)
Research, conferences, and reports on selected topics not covered in the general graduate offerings. May be taken more than once for credit.

406. Biological Seminar (1)
An advanced seminar in current developments including departmental research. Required for candidates for graduate degrees. May be taken more than once for credit.

407. Biological Research (3)
Investigations in any phase of the biological sciences according to the student's preparation and interests.

408. Biological Research (3)
Continuation of Biol 407.

409. Advanced Morphology (3)
A laboratory course in special phases of morphology, such as comparative osteology, comparative morphology, or embryology of the vertebrates, etc., to meet the individual interest of the student. Cundall

414. Advanced Ecology (3)
Seminars, conferences and directed field work with emphasis on theoretical models and their application to real biological systems. May be taken more than once for credit. Prerequisite: consent of the department chairman.

415. Cytochemistry (3)
A study of morphological and biochemical events during cell growth and differentiation including lectures, laboratories, and student reports on current literature. Special emphasis is placed on developmental patterns and laboratory procedures of the cytochemist. Prerequisite: consent of the chairman. Pritchard

416. Immunology (3)
Consideration of antigen-antibody systems from theoretical and practical aspects. Lectures and reports on the structure and origins of antigens and antibodies and the mechanisms of agglutination, precipitation, complement fixation, anaphylaxis, etc. Laboratory work on preparation, standardization, and assay of antigens and antibodies. Prerequisite: Biol 353, or Chem 371. Malsberger

417. Marine Ecology (3)
Advanced study of the physical and chemical influences in the marine environment on organisms and their interrelations. Ecological theory pertaining to population dynamics and energy flow. Prerequisite: consent of the department chairman. Herman

418. Biological Oceanography (3)
Surveys of marine plant and animal plankton, nekton and benthos. Composition of various groups, productivity, interrelationships of plants and animals and the role of microorganisms in the sea. Prerequisite: consent of the department chairman. Herman

419. Analysis of Reproduction and Mating Systems
Study of reproduction and sexuality in plants and animals with emphasis on current hypotheses as reported in the literature. Topics include hermaphroditism, neoteny, larval forms, parental investment, complex life cycles, population structure. Lecture sections may be in common with Biol 319. Readings will be from primary source material and review articles. One review paper and one research proposal are required, and together with readings, forms the basis for discussion sections and examinations. Prerequisite: consent of the department chairman. Not open to students who have taken Biol 319. Hoagland

420. Cellular Mechanisms (3)
Discussions focused on the molecular mechanisms underlying the biology of cellular and microbial systems. Specific topics emphasize the interests of the participants, but might include: microbial behavior; the evolution and genetics of subcellular specialization; active transport; nucleic acid biochemistry;

chromosome replication; cell surface specificities; the functioning of organelles; intracellular and intercellular coordination; viral specificity and reproduction. Bean

421. Morphogenesis of the Lower Invertebrates (3)
The structure and chemical aspects of normal and teratological development among the acoelomate and pseudocoelomate phyla are considered from the standpoint of cell and tissue differentiation, comparative morphological and physiological functions, exogenous stimulatory factors, and metabolic requirements. Cheng

423. The Biology of Transplantation (3)
The mechanisms, both cellular and humoral responsible for the recognition of "self" from "nonself" in the animal kingdom and the reactive processes resulting from such are explored from the viewpoint of immunity, nutritional uptake, and ontogenetic factors. Cheng

425. Biological Electron Microscopy (3)
Uses of the transmission and scanning electron microscopes in biology. Lectures and laboratory work in the preparation of biological specimens for study with both kinds of electron microscopes and independent work at both kinds of microscopes. Study of current information on cell ultrastructure. Barber or Krawiec

429. Herpetology (3)
Contains subject matter of Biol 329 plus additional work. Open only to students who have not received credit for Biol 329. Cundall

433. Growth and Development in Plants (3)
A comparative study of embryo and cellular development in the plant kingdom including the algae, bryophytes and tracheophytes. Emphasis is placed on morphology, physiology and the role of macromolecular substances during growth and differentiation. Literature search, experimental work and oral reports. Two lectures and one laboratory. Pritchard

435. Ethology (3)
Advanced topics in behavior, including stereotyped action patterns, receptor and central nervous information processing, and techniques of behavioral investigation. Seminar format. Prerequisite: consent of the department chairman. Bell

441. Marine Botany (3)
A study of the morphological, physiological, biochemical and ecological features of those plants found primarily in the salt water environment. Emphasis is placed on the evolutionary and ecological significance of the phytoplankton, benthic algae and rooted aquatic plant divisions associated in and near the oceans. The economic importance of these plants is considered. Laboratory work, field work and library searches and reports. Pritchard, Herman

442. Marine Zooplankton (3)
A comprehensive study of neritic and oceanic plankton. Studies on the life history, morphology and distribution of both holoplanktonic and meroplanktonic animals. Prerequisite: consent of the department chairman. Herman.

443. Ichthyology (3)
Lectures and laboratory on the anatomy, physiology, behavior and taxonomy of marine and freshwater fishes. Malsberger

444. (Geol 444) Multivariate Analysis (3)
The strategy of the application of multivariate analysis techniques to problems in geology and biology. Analysis of large data matrices by factor analysis, cluster analysis, discriminant function analysis, ordination and related techniques. Examples from both geology and biology. Prerequisites: Geol 10 and Geol 321 or approved equivalents. Parks, Carson

445. Nucleic Acids and Nucleic Acid Complexes (3)
Structure of DNA, replicative intermediates and chromosomes; messenger RNA, transfer RNA, ribosomal RNA, and ribosomes. Readings, lectures, and recitations. Prerequisite: consent of the department chairman. Krawiec.

447. (Chem 447) Experimental Molecular Biology (3)
A survey of current research in molecular biology.

480. (Geol 480) Marine Science Seminar (1)
An advanced interdisciplinary seminar on various problems of marine sciences, with visiting speakers and student presentations. May be substituted for Biol 406.

Chemical Engineering

Professors. Leonard A. Wenzel, Ph.D., *chairman*; Curtis W. Clump, Ph.D.; William L. Luyben, Ph.D.; William E. Schiesser, Ph.D., McCann Professor; Leslie H. Sperling, Ph.D.; Fred P. Stein, Ph.D.
Associate professors. Marvin Charles, Ph.D.; Mohamed S. El-Aasser, Ph.D.; Andrew Klein, Ph.D.; Anthony J. McHugh, Ph.D.
Assistant professor. Hugo S. Caram, Ph.D.; Cesar A. Silebi, Ph.D.
Lecturers. Jacob M. Geist, Ph.D.; Clyde McKinley, Ph.D.
Research associates. Hans Kast, Ph.D.; Subodh Misra, Ph.D.; Tuncer Ozdamar, Ph.D.

Preparation for chemical engineering requires a sound background in the fundamental sciences of physics, chemistry and mathematics plus a general background training in the application of these fundamentals to industrial production of the new products and processes discovered in the laboratory.

This latter training is directly called chemical engineering. In accord with this philosophy, the student is not trained for any specific industry, but is broadly educated so that a graduate is competent to enter any of the chemical and allied industries.

The objective of the curriculum is to develop an understanding of the scientific fundamentals, an ability with mathematical tools, and the habits of precise analysis of process engineering problems that will allow effective functioning in this broad field, and the opportunity to grow into positions of responsibility. Of course, these technical abilities must be coupled with an understanding of the economic, sociological, and cultural environment within which the engineer operates. The curriculum includes a relatively large commitment to education in these latter areas.

The program also is designed to prepare a student for graduate study in chemical engineering or in peripheral fields. Further study at the graduate level leading to advanced degrees is highly desirable in preparation for careers in the more highly technical aspects of manufacturing. The increasing complexity of modern manufacturing methods requires superior training for men and women working in the research, development, and the design fields or for teaching.

Physical facilities. The department is located in Whitaker Laboratory. In this building some 40,000 square feet of space is available for departmental research, teaching, and office needs.

The building includes specially designed facilities for analog computation, calibration standards, a minicomputer for process dynamics study, specially protected rooms for reaction kinetics and thermodynamics research, and for high pressure research, special equipment for biochemical engineering, and a wide range of general laboratory equipment for undergraduate study of the behavior of typical chemical processing units.

More complete descriptions of research equipment can be found in Section IV, graduate programs in chemical engineering.

Career Opportunities

Chemical engineers play important roles in all activities bearing on the chemical process industry. These include the functions of research, development, design, plant construction, plant operation and management, corporate planning, technical sales, and market analysis.

The industries that produce chemical and/or certain physical changes in fluids including petroleum and petrochemicals, rubbers and polymers, pharmaceuticals, metals, industrial and fine chemicals, foods, and industrial gases have found chemical engineers to be vital to their success. Chemical engineers are also

important participants in pollution abatement, energy resources, and national defense programs.

Special Programs and Opportunities

The department operates a cooperative program that is optional for specially selected students who have completed their sophomore year. This program affords early exposure to industry and an opportunity to integrate academic background with significant periods of engineering practice. Students in this program are able to earn most of their college expenses.

Opportunities for undergraduate involvement in research projects, special design projects, and programs of independent study are many, but are usually arranged specifically between a student and a professor. The high degree of curricular flexibility encourages the student to emphasize an area of special interest in the selection of electives. In some cases this may lead to a minor in addition to the chemical engineering major.

Requirements of the Major

freshman year: see Recommended Freshman Year, page 43.

sophomore year, first semester (17 credit hours)

Math 23	Analytical, Geometry and Calculus III (4)
ChE 41	Cascade Processing Concepts (3)
Chem 31	Equilibria (3)
Eco 1	Economics (4)
	elective* (3)

sophomore year, second semester (15-18 credit hours)

Math 205	Linear Methods (3)
ChE 52	Fundamentals of Transport Phenomena (4)
Chem 187	Thermodynamics (3)
Physics 21, 22	Introductory Physics II and Lab (5)
	electives * (0-3)

junior year, first semester (16 credit hours)

Chem 51, 53	Organic Chemistry and Laboratory (4)
Chem 191	Physical Chemistry (3)
ChE 167	Unit Operations (3)
	General Studies requirement (3)
	elective * (3)

junior year, second semester (16 credit hours)

Chem 192	Physical Chem Lab (2)
ChE 286	Modeling, Simulation and Control (3)
ChE 210	Thermodynamics (4)
ChE 169	Unit Operations Lab I (1)
	General Studies requirement (3)
	electives * (3-6)

junior year, summer

ChE 100	Industrial Employment

senior year, first semester (16-19 credit hours)

ChE 302	Chemical Engineering Kinetics (3)
ChE 174	Chem Plant Design (3)
ChE 170	Unit Operations Lab II (1)
	General Studies requirement (3)
	electives * (6-9)

senior year, second semester (15-18 credit hours)

	General Studies requirement (3)
	electives * (12-15)

The twenty-seven hours of electives included in the minimum degree program must be taken from the following distribution:

Chemistry: six hours

Engineering sciences: (including Mech I or Mech 103): twelve hours

Free electives: nine hours

*Please refer to description of normal program, page 43.

Undergraduate Courses

41. Cascade Processing Concepts (3) fall
Concepts of equilibrium in gas, liquid and solid systems. Engineering of sequential and cascade processing methods from technical and economic considerations. Computer modeling of leaching, extraction and distillation processes. Prerequisite: Engr 1 or equivalent in programming.

52. Introduction to Transport Phenomena (4) spring
The principles of transport of energy, momentum and mass, and the analogies between them. Transport coefficients and their evaluation. Applications in variable-property fields within a phase. Three recitations and one laboratory per week.

60. Unit Operations Survey (3) fall
The theory of heat, mass and momentum transport. Laminar and turbulent flow of real fluids. Heat transfer by conduction, convection, and radiation. Application to a wide range of operations in the chemical and metallurgical process industries.

100. Summer Employment
During the summer (preferably following the junior year) candidates for the degree of bachelor of science in chemical engineering are required to obtain industrial experience through employment for at least eight weeks in a plant, laboratory or engineering office and submit a report thereon.

167. Unit Operations (3) fall
Applications of transport phenomena and conservation principles as applied to chemical processing equipment. Prerequisite: ChE 52.

169. Unit Operations Laboratory I (1)
Laboratory experience in unit operations. Prerequisite: ChE 167 previously or concurrently.

170. Unit Operations Laboratory II (1)
Laboratory experience with steady state and dynamic process operations. Prerequisite: ChE 286 previously or concurrently.

174. Chemical Plant Design (3) fall
A study of the technical and economic aspects of the design, location and operation of chemical plants. Prerequisite: ChE 167 or ChE 286.

179. Professional Development (1) fall
Elements of professional growth, registration, ethics, and the responsibilities of engineers both as employees and as independent practitioners. Proprietary information and its handling. Patents and their importance. Discussions with the staff and with visiting lecturers. A few plant trips. Prerequisite: junior standing.

185. Undergraduate Research I (3)
Independent study of a problem involving laboratory investigation, design or theoretical studies under the guidance of a senior faculty member.

186. Undergraduate Research II (3)
A continuation of the project begun under ChE 185. Prerequisites: ChE 185 and consent of the department chairman.

For Advanced Undergraduates and Graduate Students

210. Chemical Engineering Thermodynamics (4) spring
Energy relations and their application to chemical engineering. Consideration of flow and nonflow processes. Evaluation of the effects of temperature and pressure on the thermodynamic properties of fluids. Heat effects accompanying phase changes and chemical reactions. Determination of chemical and physical equilibrium. Prerequisite: Chem 187 or equivalent.

286. Modeling, Simulation and Control (3) spring
Review of physical laws that are the basis for mathematical

models of physical systems. Mathematical modeling of important chemical engineering systems. Digital and analog computer simulation techniques for solution of ordinary differential equations describing chemical processes. Practical aspects of process control system design and operation. Exposure to control equipment: sensors, transmitters, controllers and control valves. Prerequisite: Math 205.

300. Apprentice Teaching in ChE (1-3)
See the first page of this section.

301. Process Design (3) spring
Study of the strategy of chemical process design with emphasis on optimum order of steps, flow diagrams, energy balances, recycle ratios and their effect on the economics of the operation. Survey of methods for ordering equations. Discussion of process optimization for nonlinear systems. Effects of uncertainty in process design.

302. Chemical Engineering Kinetics (3) fall
The application of chemical kinetics to the design and operation of reactors. Interrelations of kinetics, thermodynamics and unit operations. Prerequisites: ChE 167 or 286, ChE 210 or equivalent, previously or concurrently.

312. (Chem 312, Met 312) Fundamentals of Corrosion (3) fall
Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization, and passivity. Nonelectrochemical corrosion including mechanisms, theories, and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings, alloys, inhibitors, and passivators. Prerequisite: Met 210, Chem 187, or equivalent. Leidheiser or Smyth

320. Waste Water Control (3) fall
The physical processes of importance in the design of industrial waste water treatment facilities. Topics will include sedimentation and filtration processes as well as advanced methods such as adsorption, ion exchange, osmosis, foaming, freezing, and hydrate formation.

321. Fundamentals of Air Pollution (3) spring
Introduction to the problems of air pollution including such topics as: sources and dispersion of pollutants; sampling and analysis; technology of economics and control processes; legislation and standards. Prerequisite: senior standing in the College of Engineering and Physical Sciences.

331. Distillation (3)
Design and operating strategies and techniques. Computer solutions for simple and complex multicomponent distillation columns. Shortcut design methods. Tray hydraulics and constraints. Petroleum fractionators and azeotropic and extractive distillation.

340. Biochemical Engineering (3)
An introduction to various aspects of the utilization of industrially important bacteria, fungi, and yeasts. Biochemical activities and significant metabolic products of these microorganisms are discussed as are aspects of fermentor design. Consideration is given to product purification and end use. Two recitations and one laboratory period per week. Prerequisite: consent of the department chairman.

350. Special Topics (1-3)
A study of areas in chemical engineering not covered in courses presently listed in the catalog. May be repeated for credit if different material is presented.

360. (ME 360) Nuclear Reactor Engineering (3) fall-spring
A consideration of the engineering problems in nuclear reactor design and operation. Topics include reactor fuels and materials, thermal aspects, instrumentation and control problems, radiation protection and shielding, fuel processing, and reactor design. Prerequisite: senior standing in the College of Engineering and Physical Sciences.

380. Design Projects (1-6) fall-spring
Design project work as a member of a team preferably including students from different disciplines. The project attacks a problem which, when possible, involves one of the local communities or industries. Specific projects are normally guided by faculty from several departments with consultants from off the campus. The course may be repeated for credit.

386. Process Control (3) fall
Laplace transformation and transfer functions, frequency response, feedback, and feedforward control. Open-loop and closed-loop stability analysis using root locus and Nyquist techniques, design of feedback controllers with time and frequency domain specifications. Experimental process identification, introduction to sampled-data control theory. Prerequisite: ChE 286 or equivalent.

390. (Chem 390) Polymer Synthesis and Characterization (1-3) fall
Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties. Prerequisite: Chem 51, 187 or 191.

392. (Chem 392) Polymer Science (3) spring
Introduction to concepts of polymer science. Kinetics and mechanism of polymerization, synthesis and processing of polymers, characterization. Relationship of molecular conformation, structure and morphology to physical and mechanical properties. Prereuisite: Chem 187 or equivalent.

393. (Chem 393, Met 343) Physical Polymer Science (3) fall
Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline, and paracrystalline states (including viscoelastic and relaxation behavior) for single and multicomponent systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology, and behavior. Prerequisite: one year of physical chemistry.

394. (Chem 394) Organic Polymer Science (3) spring
Organic chemistry of synthetic high polymers. Functionality and reactivity of monomers and polymers. Theory of stepgrowth and chaingrowth polymerization in homogeneous and heterogeneous media. Polymerization by addition, elimination, substitution and coupling reactions. Ionic fee-radical and coordinate catalysis. Prerequisites: one year of physical chemistry and one year of organic chemistry.

Graduate Programs

The department of chemical engineering offers graduate programs leading to the master of science, master of engineering, and doctor of philosophy degrees. The programs are all custom-tailored for individual student needs and professional goals. This is made possible by a diversity of faculty interests which is broadened and reinforced by cooperation between the department and several research centers on campus.

A free flow of personnel and ideas between the centers and academic departments insures that the student will have the widest choice of research activities. The student is also exposed to a wide range of ideas and information through courses, seminars, etc., to which both faculty and center personnel contribute. In addition, strong relationships with industry are maintained by the department and the research centers, some of which operate industrially sponsored liaison programs whereby fundamental nonproprietary research is performed in areas of specific interest to participating sponsors.

Some of the centers currently operating are: Center for Health Sciences, Center for Information and Computer Science, Center for Marine and Environmental Studies, Center for Surface and Coatings Research, Center for the Application of Mathematics; Materials Research Center, and Center for Social Research.

While the department has interacted with almost all of these centers, it has had unusually strong and continuing liaisons with the Materials Research Center and the Center for Surface and Coatings Research.

In addition to interacting with the centers, the department originates and encourages programs which range from those which

are classically chemical engineering to those which are distinctly interdisciplinary. The department offers active and growing programs in: emulsion polymerization and latex technology; bulk polymer systems; process control; process improvement studies; rheology; computer applications; environmental engineering; thermodynamics; kinetics and catalysis; enzyme technology; and biochemical engineering.

Wherever possible, attempts are made to gain the cooperation and participation of other academic departments and research centers in building these programs.

Career Opportunities

Master of science and doctor of philosophy graduates in the chemical engineering area are sought by industry for activities in the more technical aspects of their operations, especially design, process and product development, and research. Many of these graduates also find opportunities in research or project work in government agencies and in university teaching and research.

Physical Facilities

The department is well equipped for research in polymer science and engineering, catalysis and reaction kinetics, thermodynamic property studies, fluid dynamics, heat and mass transfer, process dynamics and control, and enzyme engineering and biochemical engineering.

Major facilities include a PDP11/40 real time computer, differential scanning calorimeter, Phillips transmission electron microscope plus scanning attachment, RCA transmission electron microscope, ETEC scanning electron microscope, gel permeation chromatograph, intrinsic viscosity measurement, Weissenberg rheogoniometer, continuous particle electrophoresis unit, surface titration unit, preparative and analytical ultracentrifuges, liquid chromatography unit for colloid particle size analysis, polymerization reactor systems, vapor-liquid equilibria cell, PVT unit, Joule-Thomson coefficient unit, fluid-bed enzyme catalysis pilot plant, instrumented fermentation cells, hot wire anemometer, and high-pressure catalytic reaction unit.

Special Programs

Master of engineering design option. For those interested in design, the department offers the master of engineering design option. In this program, the student works on a design project proposed by the process design group of a cooperating industry. Direction of the design project is shared by the cooperating industry and a member of the faculty. Students desiring to enroll in this program should indicate that fact at the time they apply for admission.

Chemical metallurgy program. The program is jointly administered by the departments of chemical engineering and metallurgical engineering and should be particularly appealing to students interested in process metallurgy.

The student's program is arranged to supplement the bachelor of science program so that the technology of the extractive metallurgy industry is understood and the tools needed to work effectively in it are acquired. The master of science thesis is chosen from problems relevant to the metals processing industry.

Polymer science and engineering. The polymers activity at Lehigh includes work done in the Materials Research Center, the Center for Surface and Coatings Research, the Center for the Application of Mathematics, the chemistry department, and the department of chemical engineering.

About a dozen faculty members from these organizations or areas have major interests in polymers and cooperate on a wide range of research projects. For students with deep interest in the area, degree programs are available leading to the master of science and doctor of philosophy degrees in polymer science and engineering.

Research activities in which chemical engineering students and faculty are involved include a major study of impregnation of bridge decks with polymers to increase surface life; studies of the mechanism of continuous emulsion polymerization; work on polymer blends, especially interpenetrating networks, and the application of these materials to sound-deadening; rheology of viscoelastic materials; crystallization behavior from polymer melts and solutions; polymer film characteristics and the tailoring of these properties for selective transfer rates; latex film drying rates; coatings and the hiding capabilities of micropores; and the preparation of polymeric materials from agricultural raw materials.

Master of engineering degree. Students may earn the master of engineering degree in chemical engineering upon completion of a course of study and an engineering project meeting all the requirements of the master of science degree. The master of engineering student, however, elects courses closer to engineering practice, and carries out a project of more practical engineering flavor than that of the master of science candidate. In some cases the project of the master of engineering student will be done in close collaboration with local industry, as noted above.

Major Requirements

The requirements for the master of science degree are listed in the section on The Graduate School. All candidates for the master of science degree are required to complete a master of science research report for which three to six hours of graduate credit are earned. Course selection is done individually for each student, although ChE 400 and ChE 415 are considered as core courses.

The requirements for the doctor of philosophy degree also are listed in the section on the Graduate School. In addition to an approved course and thesis program, the doctor of philosophy student is expected to pass a qualification examination given within the first year of doctoral-level study, to demonstrate proficiency in one modern foreign language, and to pass a general examination based on a research proposal or independent problem presented by the student.

Advanced Courses in Chemical Engineering

400. Chemical Engineering Thermodynamics I (3) fall
Applications of thermodynamics in chemical engineering. Topics include energy and entropy, heat effects accompanying solution, flow of compressible fluids, refrigeration including solution cycles, vaporization and condensation processes, and chemical equilibria. Prerequisite: an introductory course in thermodynamics. Stein, Wenzel

401. Chemical Engineering Thermodynamics II (3) spring
A detailed study of the uses of thermodynamics in predicting phase equilibria in solid, liquid, and gaseous systems. Fugacites of gas mixtures, liquid mixtures, and solids. Solution theories; uses of equations of state; high-pressure equilibria. Stein, Wenzel

410. Chemical Engineering Kinetics (3)
The application of chemical kinetics to the engineering design and operation of reactors. Non-isothermal and adiabatic reactions. Homogeneous and heterogeneous catalysis. Residence time distribution in reactors. Prerequisite: ChE 302. Klein

413. Heterogeneous Catalysis (3)
Surface area, pore structure and pore-size distribution of catalysts. Influence of pore-diffusion on catalytic reactions and the design of catalytic reactors. Chemical adsorption and physical adsorption. Chemistry, energetics and kinetics of adsorption, desorption, and surface reaction. Electronic structure and catalysis; atomic orbital and bondstructure models. Mechanisms of catalytic reactions of industrial importance. Selection and classification of catalysts.

415. Transport Processes (3)
A combined study of the fundamentals of momentum transport, energy transport and mass transport and the analogies between them. Evaluation of transport coefficients for single and multicomponent systems. Analysis of transport phenomena through the equations of continuity, motion, and energy.
McHugh, Caram, Silebi

421. Heat Transfer (3)
Analysis of steady and unsteady state transfer. Convection, conduction, and radiation. Vaporization and condensation. Heat

transfer in high velocity flow and in rarified gases. Applications. Clump

428. Rheology (3)
An intensive study of momentum transfer in elastic viscous liquids. Rheological behavior of solution and bulk phase polymers with emphasis on the effect of molecular weight, molecular weight distribution and branching. Derivation of constitutive equations based on both molecular theories and continuum mechanics principles. Application of the momentum equation and selected constitutive equations to geometries associated with viscometric flows.

430. Mass Transfer (3)
Theory and developments of the basic diffusion and mass transfer equations and transfer coefficients including simultaneous heat and mass transfer, chemical reaction, and dispersion effects. Applications to various industrially important operations including continuous contact mass transfer, absorption, humidification, etc. Brief coverage of equilibrium stage operations as applied to absorption and to binary and multicomponent distillation. Clump, McHugh, Silebi

440. Process Design (3)
Synthesis of flow sheets for various processes, investigation of contributions to over-all economy of various alternatives. Evaluation of profitability of alternatives.

441. Advanced Process Control (3)
Sampled-data control theory with applications in digital computer control systems. Nonlinear methods of dynamic analysis. Optimal control via calculus of variations and the maximum principle. Luyben

445. Enzyme Engineering (3)
Existing and potential industrial applications of enzymes. Enzyme characteristics including nomenclature, physical properties, kinetics and assay methods with emphasis on practical application at commercial scale. Practical commercial methods of enzyme production and purification. Design of industrial-scale reactors employing soluble enzymes. Immobilized enzymes; enzyme cofactors. Charles

450. Special Topics (3-12)
An intensive study of some field of chemical engineering not covered in the more general courses. Credit above three hours is granted only when different material is covered.

451. Problems in Research (1)
Study and discussion of optimal planning of experiments and analysis of experimental data. Discussion of more common and more difficult techniques in the execution of chemical engineering research.

455. Seminar (1-3)
Critical discussion of recent advances in chemical engineering. Credit above one hour is granted only when different material is covered.

460. Chemical Engineering Project (1-6)
An intensive study of one or more areas of chemical engineering, with emphasis on engineering design and applications. A written report is required. May be repeated for credit.

461. Mathematical Methods in Chemical Engineering I (3)
Application of ordinary and partial differential equations to the solution of chemical engineering problems with emphasis on chemical reactions and transport processes as they occur in industrial chemical processing. Applications of solution in series, separation of variables, and integral transforms. Prerequisite: Math 322. Caram

464. Numerical Methods in Engineering (3) fall
Applied computer-oriented mathematics including linear difference operators, interpolation polynomials, numerical quadrature based on the Newton Cotes open and closed formulas, matrices and linear algebra with emphasis on the solution of large sparse systems, algorithms for nonlinear algebraic and transcendental systems. Computer solution of problems selected from a number of scientific and engineering disciplines. Schiesser

465. Numerical Methods in Engineering (3) spring
A continuation of ChE 464 with emphasis on the numerical integration of ordinary and partial differential equations. Topics include: single step and multistep algorithms for initial value problems in ordinary differential equations, error monitoring and control, stability and the integration of stiff systems, geometric classification of partial differential equations, explicit and implicit finite difference algorithms, convergence, consistency and stability. Schiesser

470. Cryogenic Engineering (3)
Liquefaction and separation of gases, physical and chemical principles. Low-temperature thermometry. Insulation. Properties of fluids and of structural materials. The behavior of helium. Ultra-low temperature phenomena and theories. Wenzel

471. Low-Temperature Processes (3)
The problems and design of plants operating in the cryogenic temperature range. Refrigeration demands. Distillation and heat exchange at low temperatures. Analysis of processes for thermodynamic and operating efficiency. Problems of safety, nonsteady state behavior and control. Wenzel

480. Research (3-4)
Investigation of a problem in chemical engineering.

481. Research (3-4)
Continuation of ChE 480.

482. (Chem 482, Met 482) Engineering Behavior of Polymers (3)
A treatment of the mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analogs. Topics include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizers, moisture and aging on mechanical behavior. Robinson

483. (Chem 483) Emulsion Polymers (3)
Examination of fundamental concepts important in the manufacture, characterization, and application of polymer latexes. Topics to be covered will include colloidal stability, polymerization mechanisms and kinetics, reactor design, characterization of particle surfaces, latex rheology, morphology considerations, polymerization with functional groups, film formation, and various application problems. El-Aasser, Vanderhoff, Klein

484. (Chem 484) Crystalline Polymers (3)
An in-depth treatment of the morphology and behavior of both polymer single crystals and bulk crystallized systems. Emphasis is placed on the relationship between basic crystal physics, thermal and annealing history, orientation and resulting properties. A detailed discussion of the thermodynamics and kinetics of transition phenomena and a brief treatment of hydrodynamic properties and their relationship to crystallization and processing properties. Prerequisite: ChE 392 or ChE 393 or equivalent. McHugh

485. (Chem 485) Polymers Blends and Composites (3)
An intensive study of the synthesis, morphology, and mechanical behavior of polymer blends and composites. Mechanical blends, block and graft copolymers, interpenetrating polymer networks, polymer impregnated concrete, and fiber and particulate reinforced polymers are emphasized. Prerequisite: any introductory course in polymers. Manson, Sperling

492. (Chem 492) Topics in Polymer Science (3)
Intensive study of topics selected from areas of current research interest such as morphology and mechanical behavior, thermodynamics and kinetics of crystallization, new analytical techniques, molecular weight distribution, non-Newtonian flow behavior, second-order transition phenomena, novel polymer structures. Credit above three hours is granted only when different material is covered. Prerequisite: Chem 392 or equivalent.

Chemistry

Professors. Frederick M. Fowkes, Ph.D., *chairman*; Albert C. Zettlemoyer, Ph.D., distinguished professor, vice president and provost; Eugene M. Allen, Ph.D.; Thomas C. Cheng, Ph.D., director, Center for Health Sciences; Charles S. Kraihanzel, Ph.D.; Ned D. Heindel, Ph.D., Howard S. Bunn distinguished professor of chemistry and director, Division of Biological Chemistry and Biophysics, Center for Health Sciences; Kamil Klier, Ph.D.; Henry Leidheiser, Jr. Ph.D., director, Center for Surface and Coatings Research; Roland W. Lovejoy, Ph.D.; John A. Manson, Ph.D., director of the Polymer Laboratory, Materials Research Center; Joseph R. Merkel, Ph.D.; William E. Ohnesorge, Ph.D.; Donald M. Smyth, Ph.D., director, Materials Research Center; Robert S. Sprague, Ph.D.; James E. Sturm, Ph.D.; John W. Vanderhoff, Ph.D., director, Emulsion Polymers Institute, and associate director, Center for Surface and Coatings Research; Thomas E. Young, Ph.D.
Associate professors. Fortunato J. Micale, Ph.D.; Stephen W. Schaffer, Ph.D.; Keith J. Schray, Ph.D.; Gary W. Simmons, Ph.D.; Daniel Zeroka, Ph.D.
Assistant professors. Michael C. Hughes, Ph.D.; Robert S. Rodgers, Ph.D.
Visiting lecturers. John W. LeMaistre, Ph.D.; Heinz G. Pfeiffer, Ph.D.; Courtland N. Robinson, Ph.D.

Range of Opportunities

Chemistry is a basic science of such intellectual challenge that most graduates continue study for advanced degrees, yet it is so practical that 200,000 chemists provide the technical backbone of the manufacturing industries.

Students majoring in chemistry receive an education which provides a broad base for further specialization in a wide variety of careers. A degree in chemistry (with biology electives) is the strongest preparation for medical school, and an excellent background for graduate studies in other heath-related disciplines (biochemistry, pharmacology, immunology, pathology, etc.). Graduate schools accept chemistry majors into a variety of other programs (physics, materials engineering, oceanography, environmental studies, mineralogy, etc.).

Within the field of chemistry, graduates are prepared for research (in universities, government laboratories, or industrial laboratories), for teaching (in universities, colleges, or high schools), for industrial positions (in product development, sales, or management) and for government positions (pollution control, Food and Drug Administration, etc.).

Most chemists are employed in manufacturing industries (pharmaceuticals, plastics, fibers, rubber, paper, coatings, electronics, automobiles, aircraft, petroleum, agricultural chemistry, etc.) and in many of these industries chemists rise to top management positions.

The undergraduate curriculum in chemistry contains many of the prerequisites for biology, geological sciences, metallurgy, physics, and chemical engineering so that students can easily transfer with no loss of credits, even in the junior year.

Chemistry students have the opportunity to design their undergraduate curricula for specialization in a variety of fields:

Health-related chemistry (including premedical students)
Suggested biology electives: 21, 22, 35, 320, 353
Suggested chemistry electives: 336, 371, 372, 377, 378
Suggested physics electives: 367, 368
The above electives may be used in place of German, provided that an equal number of credits of General Studies are added.

Materials chemistry (polymers, solid state, surfaces)
Suggested physics electives: 31, 363
Suggested chemistry electives: 312, 390, 392, 393, 394, 395, 396

Environmental chemistry
Suggested biology electives: 21, 22, 35, 306
Suggested chemical engineering electives: 320, 321
Suggested chemistry electives: 303, 334, 395, 310
The above electives may be used in place of German, provided that an equal number of credits of General Studies are added.

Geochemistry
Suggested geology electives: 333, 334, 336, 352, 372
Suggested chemistry electives: 303, 396
The above electives may be used in place of German, provided that an equal number of credits of General Studies are added.

Chemistry management
Suggested mathematics substitution: 231 for 205 (permits B.S. plus M.B.A. in five years)
Suggested accounting electives: 108, 111
Suggested law elective: 101
Suggested management electives: 201, 302
Suggested chemistry electives: 390, 392, 395
Suggested economics electives: 129, 206
Suggested marketing elective: 211
Suggested finance elective: 225
The above electives may be used in place of German, provided that an equal number of credits of General Studies are added.

Accelerated Programs

A three-year bachelor of science degree and a four-year master of science degree in chemistry are available as part of the seven-year bachelor of science and doctor of medicine plan of Lehigh and Hahnemann Medical College. See Health Professions, Section III. Eligibility is limited to students entering the university with credit for Chem 21 and 22.

The Five-Year Program

Five-year programs are available for students to receive bachelor of science or bachelor of arts degrees and the master of science degree in several fields of chemistry (inorganic, organic, analytical, or physical chemistry, polymers, or biochemistry). A five-year program also is available for a bachelor of science degree in chemistry and a master in business administration (M.B.A.); graduates of this program have been unusually successful in securing well-paid jobs.

B.A. and B.S. Degrees in Chemistry

Lehigh University offers a bachelor of arts degree in chemistry from the College of Arts and Science and a bachelor of science degree in chemistry from the College of Engineering and Physical Sciences.

In most classes, the bachelor of science candidates outnumber the bachelor of arts candidates in chemistry, but not always. The required courses in science and mathematics are identical for the two programs; these are shown in the recommended sequence of courses for the bachelor of science degree. The difference in the two programs lies in the distribution of courses in the humanities and social sciences.

German is not required for the bachelor of arts degree. It is a normal requirement for the bachelor of science degree, but substitutions are possible. The bachelor of arts degree requires 120 semester hour credits and the bachelor of science degree requires 128 semester hour credits. Students continuing in graduate school at Lehigh or who have appropriate noncredit educational experiences may graduate with as few as 121 credits upon approval of the dean of the college.

Recommended Sequence of Courses for the Bachelor of Science Degree in Chemistry

freshman year (see page 43) (31 credit hours)

sophomore year, first semester (17 credit hours)

Chem 31	Chemical Equilibria (3)
Chem 51	Organic Chemistry (3)
Chem 53	Organic Chemistry Lab (1)
Chem 57	Organic Synthesis Lab (1)

Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
Math 23	Analytical Geometry and Calculus III (4)

sophomore year, second semester (15 credit hours)

Chem 52	Organic Chemistry (3)
Chem 54	Organic Chemistry Lab (2)
Chem 187	Physical Chemistry (3)
Math 205	Linear Methods (3)
Eco 1	Economics (4)

junior year, first semester (15 credit hours)

Chem 188	Physical Chemistry Lab (2)
Chem 191	Physical Chemistry (3)
Chem 234	Analytical Chemistry Lab (1)
Chem 332	Analytical Chemistry (3)
Chem 358	Advanced Organic Chemistry (3)
Ger 1	Elementary German (or approved substitutes) (3)

junior year, second semester (15 credit hours)

Chem 307	Inorganic Chemistry (3)
Chem 384	Advanced Chemical Experimentation (2)
Chem 338	Advanced Analytical Chemical Lab (1)
German 2	Elementary German (or approved substitute) (3)
	General Studies requirement (6)

senior year, first semester (18 credit hours)

Chem 381	Radiation and Structure (3)
Chem	elective (3)
	electives (12)

senior year, second semester (17 credit hours)

Chem	elective (2)
	electives (15)

Chemistry electives are any two courses (200 to 400 level) in science or engineering; at least one must include a laboratory. Note: If German courses are substituted, General Studies must be added.

B.S. Degree in Biochemistry

The undergraduate curriculum leading to a bachelor of science degree in biochemistry is based on the standard freshman year and the normal sophomore year of the chemistry curriculum.

Concentration in biochemistry courses takes place in the junior and senior years at the expense of some electives and of two courses in the normal chemistry curricula. Consequently, graduates of this program are prepared to go into graduate work in several fields (medicine, biochemistry, chemistry, biophysics and biology).

This curriculum requires 129 semester-hour credits. Students continuing in graduate school at Lehigh or who have appropriate noncredit educational experiences may graduate with as few as 121 credits upon approval of the dean of the college.

Recommended Sequence of Courses for the Bachelor of Science Degree in Biochemistry

freshman year (see page 43) (31 credit hours)

sophomore year, first semester (17 credit hours)
same as chemistry

sophomore year, second semester (18 credits)

Chem 52	Organic Chemistry (3)
Chem 54	Organic Chemistry Laboratory (2)
Chem 187	Physical Chemistry (3)
Math 205	Linear Methods (or approved substitutes) (3)
Eco 1	Economics (4)
Bio 21	Principles of Biology (3)

junior year, first semester (16 credit hours)

Chem 191	Physical Chemistry (3)
Chem 234	Analytical Chemistry Laboratory (1)
Chem 332	Analytical Chemistry (3)
Chem 371	Biochemistry I (3)
Chem 377	Biochemistry Lab (3)
Ger 1	Elementary German (or approved substitute) (3)

junior year, second semester (17 credit hours)

Chem 307	Inorganic Chemistry (3)
Chem 384	Advanced Chemical Experimentation)3)
Chem 338	Advanced Analytical Chemistry Lab (1)
Chem 372	Biochemistry II (3)
Ger 2	Elementary German (or approved substitute) (3)
Biol	elective (3) *or*
Biophys	elective (3)

senior year, first semester (15 credit hours)

Chem 358	Advanced Organic Chemistry (3)
Biol	elective (3)
Biochem	elective (3) *or*
Biophys	elective (3)
	General Studies requirement (3)
	electives (3)

senior year, second semester (15 credit hours)

Biophys	elective (3)
Biochem	elective (3) *or*
Biophys	electives (3)
	General Studies requirement (3)
	electives (6)

Biology electives include Biol 21, 28, 35, 320, 353; nine credits required. Biophysics electives include Phys 367, 368 (Chem 303 also is approved); three credits required.
Biochemistry electives include Chem 378, 350, 375; two credits required. Note: If German courses are substituted, General Studies courses must be added.

Undergraduate Courses in Chemistry

21. Introductory Chemical Principles (4) fall-spring
An introduction to certain important principles of chemistry. Topics include atomic structure and bonding, stoichiometry, states of matter, and introductions to kinetics, chemical equilibrium, acid-base theories, oxidation-reduction reactions, and galvanic cells. Math 21, 31, or 41 previously or concurrently. Two lectures, two recitations. Sprague

22. Chemical Principles Lab (1) fall-spring
A laboratory course to be taken concurrently with Chem 21. An introduction to chemical laboratory techniques with emphasis on quantitative measurements. One three-hour laboratory period per week. Sprague

23. Environmental Aspects of Analytical Chemistry (3) spring
The fundamentals, theory, and practice of the analytical chemical methods used to examine air, water, and soil samples for the trace impurities. Selected topics in the areas of classical and instrumental methods. Prerequisite: Chem 21. Hughes

31. Chemical Equilibria in Aqueous Systems (3) fall-spring
Mass law calculations involving acid-base, solubility, complexation and oxidation-reduction equilibria in aqueous solution. Introduction to the thermodynamics of chemical systems. Descriptive chemistry of familiar representative elements and certain of the transition metal elements with emphasis on behavior in aqueous systems. The laboratory work emphasizes qualitative and quantitative analysis. Prerequisites: Chem 21, Math 21, Phys 11. Two lectures, one three-hour recitation-laboratory period per week. Sprague

39. Analytical Chemistry (3) spring
The fundamentals, theory, and practice of analytical chemistry for all students except chemistry majors. Selected topics in the areas of

classical and instrumental analysis. Fundamental techniques are presented in the laboratory. Two lectures, one laboratory period. Prerequisite: Chem 21. Hughes, Ohnesorge or Rodgers

51. Organic Chemistry (3) fall
Systematic survey of the typical compounds of carbon, their classification, and general relations; study of synthetic reactions. Prerequisite: Chem 21. Heindel, Schray or Young

52. Organic Chemistry (3) spring
Continuation of Chem 51. Prerequisite: Chem 51.

53. Organic Chemistry Laboratory (1) fall
Preparation of pure organic compounds. Prerequisite: Chem 21. Heindel, Schray or Young

54. Organic Chemistry Laboratory (2) spring
Continuation of Chem 53 with particular emphasis upon aromatic compounds and qualitative organic analysis. Prerequisite: Chem 53 previously; Chem 52 concurrently. Heindel, Schray or Young

55. Organic Chemistry Laboratory (2) spring
A course in the preparation of pure organic compounds and the techniques of organic chemistry applicable to both aliphatic and aromatic compounds. Prerequisites: Chem 51 and Chem 52 concurrently. Heindel, Schray or Young

57. Organic Synthesis Laboratory (1) fall
A course in preparative reactions and techniques for organic compound synthesis with emphasis on aromatic compounds. Intended for chemistry majors only. Prerequisite: Chem 53 concurrently: consent of the chairman. Heindel, Schray or Young

187. Physical Chemistry (3) spring
Development of the principles of thermodynamics and their application to systems in which composition is of major concern: solutions, chemical and phase equilibria. Elements of chemical reaction kinetics. Discussion of various states of matter (gases, liquids, solids, interfaces). Prerequisites: Chem 31, or Met 210, and Math 21 or 43 previously or concurrently. Lovejoy or Zeroka

188. Physical Chemistry Laboratory (2) fall
Primarily for majors in chemistry. Quantitative observation of properties of matter and of dynamic processes involving composition, the relation of observations to conceptual models. Methods of data acquisition, treatment, assessment. Two three-hour labs per week. Prerequisite: Chem 187. Sturm

191. Physical Chemistry (3) fall
Quantum chemistry of bonding and molecular structure. Elements of statistical thermodynamics. Prerequisites: Chem 21, Math 23 and Phys 21. Lovejoy or Zeroka

192. Physical Chemistry Laboratory (2)
This course provides a series of laboratory studies which illustrate the various fields of study in experimental physical chemistry. Prerequisite: Chem 187. Sturm

193. Environmental Science Seminar (Biol 191, Geol 191) (1) fall and spring
Current developments in environmental science presented by students and discussed in seminar style. An interdisciplinary approach linking biological, geological and chemical principles as they relate to causes and controls of environmental problems. May be taken more than once for credit. Prerequisite: sophomore standing. Hughes

194. Physical Chemistry for Biological Sciences (3) spring
The principles and applications of physical chemical concepts to systems of biological interest, including the gas laws, thermodynamics of metabolic reactions, colligative properties, electrochemical equilibria, reaction kinetics and enzyme catalysis, and transport of macromolecules and viruses. Prerequisite: Chem 21. Fowkes

207. Metallic Elements (3) fall
A systematic study of the inorganic chemistry of the metallic elements and their major compounds with emphasis on the properties and structures of solid materials. Grouping of elements with similar properties within the periodic table will be stressed. Prerequisite: Chem 21. Smyth

234. Analytical Chemistry Laboratory (1)
Laboratory course: experiments coordinated with and illustrating methods and principles discussed in Chem 332. Hughes, Ohnesorge, Rodgers

250. Special Topics (1-3)
Selected topics in chemistry. May be repeated for credit when different topics are offered.

300. Apprentice Teaching in Chemistry (1-3)
See the first page of this section.

303. Nuclear and Radiochemistry (3)
A broad survey of nuclear science with particular emphasis on aspects of importance to chemistry and biology. Elementary nuclear theory; production, separation, and identification of radioactive and stable isotopes; use of isotopes in the study of chemical and biological systems; radiological safety; nuclear engineering. Two lectures and one lecture-laboratory. Sturm

307. Advanced Inorganic Chemistry (3) spring
Selected topics in inorganic chemistry. Descriptive chemistry of the representative elements; introduction to transition metal complexes and the theories of bonding in these substances; kinetics and mechanisms of transition metal complex reactions; selected aspects of organometallic chemistry; bioinorganic chemistry. Prerequisite: Chem 191. Kraihanzel

310. Instrumentation Principles I (3) fall
Introduction to electronic instrumentation. Operational amplifiers and instrument design. Laboratory includes the design and construction of a useful electronic instrument of the student's choice. Typical project possibilities: EKG amplifier; analog computer for solving equations of state; electrochemical waveform generator. No prior electronics experience needed. Two lectures and one three-hour laboratory. Rodgers

311. Instrumentation Principles II (3) spring
A continuation of Chem 310 emphasizing digital electronics. Digital-analog and analog-digital conversion. Introduction to microprocessors and microcomputers. The laboratory includes a design and construction project. Typical project possibilities include an alphanumeric oscilloscope display interface and a hardware multiply/divide unit for a microprocessor. Two lectures and one three-hour laboratory. Prerequisite: Chem 310 or equivalent with permission of the department chairman. Rodgers

312. (ChE 312, Met 312) Fundamentals of Corrosion (3) fall
Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization, and passivity. Nonelectrochemical corrosion including mechanisms, theories, and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings, alloys, inhibitors, and passivators. Prerequisites: Met 210, Chem 187, or equivalent. Leidheiser

332. Analytical Chemistry (3) fall
Theory and practice of chemical analysis. Principles of quantitative separations and determinations; theory and application of selected optical and electrical instruments in analytical chemistry; interpretation of numerical data, design of experiments, solute distribution in separation methods. Prerequisites: Chem 31 and 51. Ohnesorge or Rodgers

334. Chemical Oceanography (3)
Chemistry of the oceans and other natural water systems, with emphasis on processes occurring at the interfaces with the air, the sediments, the rivers, and living organisms. Prerequisite: two chemistry courses or consent of the chairman. Hughes

336. Clinical Chemistry (3) spring
Applications of analytical chemistry to clinical problems. Discussion of methods in common use and the biochemical-medical significance of the results. Prerequisites: Chem 39 or Chem 332 and Chem 52. Ohnesorge

338. Advanced Analytical Chemistry Laboratory (1) spring
A laboratory course in continuation of Chem 234. Experiments coordinated with and illustrating methods and principles discussed in Chem 332. Emphasis on spectrochemical, electroanalytical, and chromatographic techniques. Prerequisites: Chem 234 and Chem 332. Hughes, Ohnesorge and Rodgers

340. The Chemist in Industry (2) spring
Structure and specific features of the chemical industry (raw materials, products, processes, markets, elements of cost, competition, patents, safety, governmental regulation, use of research); decision-making and development of new products, processes, and uses; industrial careers for chemists; preparation for job interviews. LeMaistre or Vanderhoff

350. Special Topics (1-3)
Selected advanced topics in chemistry. May be repeated for credit when different topics are offered.

358. Advanced Organic Chemistry (3) fall
The study of modern theories of reaction mechanisms and their applications to the problems of organic chemistry. Prerequisite: one year of organic chemistry. Heindel or Young

368. Advanced Organic Laboratory (2)
The synthesis and study of organic compounds illustrating the important techniques and special pieces of apparatus commonly used in organic chemical research. Prerequisite: one year of organic chemistry and laboratory.

371. (Biol 371) Elements of Biochemistry I (3) fall
A general study of carbohydrates, proteins, lipids, nucleic acids, and other biological substances and their importance in life processes. Protein and enzyme chemistry are emphasized. Prerequisite: one year of organic chemistry. Merkel or Schaffer

372. (Biol 372) Elements of Biochemistry II (3) spring
Dynamic aspects of biochemistry: enzyme reactions including energetics, kinetics, and mechanisms; metabolism of carbohydrates, lipids, proteins, and nucleic acids; photosynthesis, electron transport mechanisms, coupled reactions, phosphorylations, and the synthesis of biological macromolecules. Prerequisite: Chem 371. Merkel or Schaffer

375. Research Chemistry Laboratory (3) fall-spring
Advanced independent study or an investigation involving intensive work with faculty guidance in laboratory and library. Topics in active research in biochemistry, analytical, inorganic, organic, and physical chemistry. Prerequisite: consent of the department chairman.

377. Biochemistry Laboratory (3) fall
Laboratory studies of the properties of chemicals of biological origin and the influence of chemical and physical factors on these properties. Laboratory techniques used for the isolation and identification of biochemicals. Prerequisite: Chem 371, previously or concurrently. Merkel or Schaffer

378. Biochemical Preparations (2) spring
A laboratory course involving the preparation or isolation, purification and identification of chemicals of biological origin. Prerequisites: Chem 377 and 372, previously or concurrently. Merkel, Schaffer

381. Radiation and Structure (3) fall
Quantum chemistry and group theory applied to molecular orbital theory of bonding and structure and to spectroscopy: X-ray, electron, luminescence, Raman, microwave. Prerequisites: Chem 191 and Math 205. Klier

382. Electrochemistry and Kinetics (3-4)
A unified study of matter in the process of change. Elements of irreversible thermodynamics; electrochemistry; chemical kinetics; electrokinetic phenomena. Three one-hour lectures and (optional) three-hour laboratory. Prerequisites: Chem 187 and 332. Sturm

384. Advanced Chemical Experimentation (2) spring
An advanced laboratory course integrating library research and various aspects of chemical syntheses, separations, purification methods, physical techniques, and spectral characterization (infrared, electronic, nuclear magnetic resonance mass spectrometry, Mossbauer, electron spin resonance) through the pursuit of mini-research problems in the areas of inorganic chemistry and organometallic chemistry. Prerequisites: Chem 188 and 307, previously or concurrently. Kraihanzel

385. Physical Chemistry of Printing Inks (3) fall
Physical chemical mechanisms of printing processes; composition, dispersion processes for pigments, rheology and printability of inks; color-matching; development of solventless inks and specialty inks. Vanderhoff

386. Catalysis (1-3) spring
Kinetics and thermodynamics of chemisorption and catalyzed reactions. The relation between the electronic and geometric structure of the catalyst and its selectivity to a desired product. Current and prospective major industrial processes will be discussed from fundamental chemical and physical principles. Prerequisite: Chem 187 or equivalent. Klier

390. Polymer Synthesis and Characterization (3) spring
Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties; Prerequisites: Chem 187, 191 and 51. Manson

392. (ChE 392) Introduction to Polymer Science (3) fall
Introduction to concepts of polymer science. Kinetics and mechanism of polarization; synthesis and processing of polymers, characterization. Relationship of molecular conformation, structure and morphology to physical and mechanical properties. Prerequisite: Chem 187 or equivalent. Manson, Sperling

393. (ChE 393, Met 343) Physical Polymer Science (3) fall
Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline, and paracrystalline states (including viscoelastic and relaxation behavior) for single and multicomponent systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology and behavior. Prerequisite: one year of physical chemistry. Manson, Sperling

394. (ChE 394) Organic Polymer Science (3) spring
Organic chemistry of synthetic high polymers. Functionality and reactivity of monomers and polymers. Theory of stepgrowth and chain-growth polymerization in homogeneous and heterogeneous media. Polymerization by addition, elimination, substitution, and coupling reactions. Ionic, free-radical, and coordination catalysis. Prerequisites: one year of physical chemistry and one year of organic chemistry. Manson, Vanderhoff

395. Colloid and Surface Chemistry (3) fall
Physical chemistry of everyday phenomena. Intermolecular forces and electrostatic phenomena at interfaces, boundary tensions and films at interfaces, mass and charge transport in colloidal suspensions, electrostatic and London forces in disperse systems, gas adsorption, and heterogeneous catalysis. Prerequisite: Chem 187 or equivalent. Fowkes

396. Chemistry of Nonmetallic Solids (3) spring
Chemistry of ionic and electronic defects in nonmetallic solids and their influence on chemical and physical properties. Intrinsic and impurity controlled defects, nonstoichiometric compounds, defect interactions. Properties to be discussed include: diffusion, sintering, ionic and electronic conductivity, solid-state reactions, and photoconductivity. Prerequisite: Chem 187 or Met 210 or equivalent. Smyth

Graduate Programs in Chemistry

The department of chemistry offers graduate studies leading to several advanced degrees. In addition to the traditional master of science and doctor of philosophy degrees in chemistry, the department also offers a doctor of arts degree in chemistry (primarily for college-level chemistry teachers), a master of science

and doctor of philosophy degree in physiological chemistry (primarily for certain specialties in the health sciences), and a master of science and doctor of philosophy degree in molecular biology.

Most of the chemistry facilities are housed in the 90,000-square-foot chemistry complex, first occupied in 1975. The seven-story Seeley G. Mudd Building affords laboratory space of modern design; the top three floors are devoted to research laboratories. Most of the research laboratories in the adjacent Sinclair Laboratory are assigned to chemistry professors who specialize in research in surface and colloid chemistry.

Physiological chemistry research is located in Chandler-Ullmann Hall and in the Seeley G. Mudd Building. Solid-state chemical research is located in the Sherman Fairchild Laboratory, in Coxe Laboratory, in the Seeley G. Mudd Building, and in Sinclair Laboratory. Polymer chemistry research laboratories are located in Coxe Laboratory, Sinclair Laboratory, and the Seeley G. Mudd Building.

The graduate program in chemistry at Lehigh has a two-fold purpose. It affords a student the opportunity to acquire an advanced knowledge of chemistry within the framework of formal graduate courses and permits the development of competent research techniques through independent scientific investigation. The graduate program for the doctor of philosophy degree in chemistry consists of approximately one-third formal course work and two-thirds independent research and study. A student entering graduate study with a teaching assistantship spends an average of four years of full-time residency beyond the bachelor's degree to complete all the requirements for the Ph.D. degree.

During the first year of graduate work, a student normally takes basic graduate courses from the fields of analytical, biological, inorganic, organic, and physical chemistry and becomes acquainted with the research interests of the faculty members. From these contacts the student is able to assess critically an individual research interest, and thus choose a research director. A research problem is agreed upon with a research director, and a thesis committee is appointed to serve in an advisory capacity.

It is assumed that an entering graduate student in chemistry has satisfied the requirements for the bachelor's degree that meet the minimum standards recommended by the American Chemical Society committee on professional training. Thus, in addition to the usual chemistry courses, a student's undergraduate curriculum should include at least one year of physics and mathematics through calculus. If a deficiency is shown in one or more of these undergraduate areas, it can be rectified during the first year of graduate work and will not affect a student's eligibility for an appointment to an assistantship.

Teaching and research assistantships, as well as fellowships, are available to graduate students in chemistry. The assistantships are regarded as half-time appointments, permitting a student to enroll for up to ten credit hours of course work per semester. Students on teaching appointments normally have an average of eight hours per week of instructional duties in undergraduate recitation classes or laboratories. The university does not charge tuition or other fees of students on teaching appointments.

Seventy-five students are enrolled in graduate studies in chemistry. Twenty-three have teaching assistantships, twenty have research assistantships, six have fellowships, and twenty are part-time students working in local industrial laboratories. Usually there are more research assistantships available than applicants. Students on research assistantships tend to progress faster towards their degrees than those who are teaching assistants; they become educated in subjects of greater interest to potential employers.

The department has about $1 million in research funding per annum, mostly in research on polymers, surface and colloid chemistry, catalysts and solid-state chemistry, physiological, organic, biochemical, and pharmaceutical chemistry. Students specializing in these fields will have the best chance of research assistantships. Several fellowships in energy-related research, especially catalysis, are available.

Current Research Projects

Current research projects of interest are listed below.

Analytical chemistry. Gas chromatograph-mass spectroscopy of trace organics, electrochemical reduction and oxidation mechanisms of organic compounds, luminescence of metal chelates, voltammetry in nonaqueous solvents, clinical-biomedical applications, mechanisms of electrode processes, adsorption, chemistry of amalgams, metal-organic interactions in the environment; environmental analytical chemistry (electrochemical, atomic absorption and chromatographic techniques); redox behavior of transition metal complexes.

Biochemistry. Production, isolation and characterization of proteolytic enzymes of marine bacteria; determination of the amino acid specificity of bacterial proteases; mechanism of action of proteolytic enzymes, cardiac metabolism and enzymology; enzyme kinetics; protein structure and reconstitution; sugar phosphate substrate utilization by glycolytic enzymes; mechanism of phosphoglucose isomerase and aldolase; phosphoryl transfer reactions of enzyme; membrane receptors, biochemistry of taurine in heart failure.

Inorganic chemistry. Synthesis and characterization of amide complexes of transition metals; silicon organometallic compounds; substitution and rearrangement reactions involving metal carbonyls; organic syntheses and catalysis involving transition metal complexes.

Organic chemistry. Synthesis of medicinal agents; correlation of molecular structure with pharmacological behavior; chemical models for biochemical reactions; sulfur bonding in novel heteroaromatic sulfur compounds; biosyntheses involving indole intermediates; mechanism of formation and structure of melanin; synthesis of new heterocyclic systems; mechanisms of phosphoglucose isomerase and aldolase; synthesis and phosphoryl transfer of phosphate esters of biological interest; radio pharmaceuticals.

Physical chemistry. Lehigh operates one of the half-dozen leading laboratories in the world in surface and colloid chemistry and students in these specialties have many employment opportunities. Research areas include latex research, surface coatings, colloidal stability, adhesion, surface properties of catalysts, surface spectroscopy, surface colorimetry, and ice nucleation. Solid-state chemistry is also noteworthy and includes studies of point defects in oxides, oxide growth, and surface spectroscopy. Other fields include flash photochemistry and kinetic spectroscopy, structure determination (bond lengths and angles) of gaseous compounds from vibration-rotation spectra using infrared spectroscopy, and applications of quantum mechanics and statistical mechanics to problems of chemical interest.

Polymer chemistry. Lehigh staff members are recognized internationally in several aspects of the synthesis, structure, conformation, and properties of high polymers: techniques and kinetics of emulsion polymerization and film formation; acoustic, optical, permeability, dielectric, and mechanical behavior of thin films, coatings and bulk polymers; molecular structure, relaxation behavior, and energetics of fracture; elastic and viscoelastic behavior of interpenetrating and rubbery networks; effects of ordering in the glassy state and crystallization on physical properties; crystallization under the influence of shear gradients; physical chemistry of polymer composites such as polymer-concrete and filled polymers; interfacial characteristics and interactions in polymer-inorganic systems. Students specializing in polymer research at Lehigh have many employment opportunities.

Major Instrumentation

Special equipment available for graduate research in chemistry includes a computer terminal in the chemistry complex. Other equipment is as follows:

Electron microscope, scanning electron microscope, electron microprobe, optical microscopes, precision mass spectrometer, Finnegan GC mass spectrometer, nuclear magnetic resonance spectrometer, electron spin resonance spectrometer, various double-beam infrared, visible, and ultraviolet spectrometers, Fourier transform infrared interferometer, atomic absorption spectrometers, spectrofluorometers, phosphorescence spectrometer, Auger spectrometer, physical electronics ESCA spectrometer, secondary ion mass spectrometer, scanning auger spectrometer, Mossbauer spectrometer, automatic multichannel scintillation counter, radiotracer equipment, flash photolysis apparatus, light-scattering photometer, preparative, analytical, and disc ultracentrifuges, analytical and preparative gas chromatographs, Vibron elastoviscometers, Weissenberg rheogoniometer, differential scanning calorimeter and other thermoanalytical equipment, gel permeation chromatograph, torsional modulus apparatus, vapor and liquid permeability equipment, dielectric capacitance bridges, MTS closed-loop hydraulic tester, torsion tensile testers, high-temperature tube

furnaces, capacitance-voltage testing equipment, cobalt-60 gamma ray source, Wenking potentiostat, recording-multipurpose polarographs, and chronopotentiometers, high-speed centrifuges, automatic fraction collectors, freeze dryers, high-voltage electrophoresis apparatus, laboratory fermentor, three work-in cold rooms, cell disintegrator, Warburg respirometer, zone and disc electrophoresis apparatus, paper column chromatography equipment, and an autoclave.

Graduate Courses in Chemistry

402. Physical Inorganic Chemistry (3) alternate years
Theories of bonding. Group theoretical principles will be utilized in studies of molecular orbital and ligand field theories of bonding. Prerequisite: Chem 191 or equivalent. Klier

403. Advanced Topics in Inorganic Chemistry (1-3) alternate years
Topics of contemporary interest in inorganic chemistry. This course may be repeated when a different topic is offered. Prerequisite: Chem 307 or equivalent. Klier, Kraihanzel, Sprague

405. Organometallic Chemistry (3) alternate years
The chemistry of compounds containing carbon to metal bonds. Among topics covered are the following: organic compounds of the representative elements from Groups I-IV; the chemistry of ferrocene and related pi-bonded organometallic complexes; metal carbonyl and nitrosyl complexes; dioxygen and dinitrogen complexes; organic syntheses utilizing organometallic catalysts. Prerequisites: Chem 307 and 358. Kraihanzel

407. Mechanisms of Inorganic Reactions (3) alternate years
A study of the experimental and theoretical evidence for the following types of inorganic reaction mechanisms: proton transfer and Bronsted acid-base catalysis, nucleophilic and electrophilic displacements, Lewis acid-base catalysts, electron and atom transfer in oxidation-reduction reactions, free radical reactions, elimination reactions. Emphasis is on homogenous reactions in solution or the gas state. Mechanisms involving both transition and nontransition elements are discussed. Prerequisite: Chem 307 or equivalent. Kraihanzel

411. Teaching Internship (3-6) fall-spring
The preparation, teaching and grading of one or two undergraduate lecture courses with appropriate supervision by senior faculty. Observation and evaluation of the intern is effected by classroom visits and videotape review. Prerequisite: candidacy in the doctor of arts program or permission of the department chairman. May be repeated for credit.

421. Chemistry Research (1-6)
Research in one of the following fields of chemistry: analytical, inorganic, organic, physical, polymer, biochemistry.

423. Bio-organic Chemistry (3) alternate years
An examination of biochemistry on the basis of organic chemical principles. Emphasis on reaction mechanisms of biochemical transformations and methods for elucidation of these mechanisms, i.e. kinetics, isotope effects, exchange techniques, inhibition studies, substrate analog effects, and organic model studies. Prerequisite: Chem 358. Schray

424. Medicinal and Pharmaceutical Chemistry (3) alternate years
Principles of drug design, structure-activity relationships in antibacterial, antimalarial, anti-inflammatory, and psychoactive drugs; syntheses and modes of action of pharmacologically active agents, radioactive pharmaceuticals. Prerequisite: one year of organic chemistry. Heindel

432. Advanced Analytical Chemistry (3) alternate years
Recent developments in analysis by chemical methods. Statistical methods in analytical chemistry: treatment and interpretation of numerical data; design of experiments; application to and discussion of multistage and other methods for separating chemical species. Prerequisite: Chem 332 or equivalent. Hughes, Ohnesorge, Rodgers

433. Advanced Topics in Electrochemistry (3) alternate years
Theory and applications of selected electrochemical techniques; solutions to mass transport problems, treatment of electron transfer kinetics and kinetics of associated chemical reactions, and critical evaluation of adsorption and other factors associated with electrochemical processes. Prerequisite: Chem 332 or equivalent. Rodgers

436. Special Topics in Analytical Chemistry (1-3)
Topics of contemporary interest in analytical chemistry. May be repeated for credit when a different topic is offered. Hughes, Ohnesorge, Rodgers.

441. Chemical Kinetics (3) alternate years
A study of kinetic processes. Phenomenological chemical kinetics; order, mechanism effect of external variables on rate. Theories of the rate constant. Relation between thermodynamics and kinetics. Applications to selected systems such as unimolecular decompositions, adsorption and catalysis. Prerequisite: one year of physical chemistry. Sturm

443. (Met 433) Solid State Chemistry (3) alternate years
Crystal structure, diffraction in crystals and on surfaces, bonding and energy spectra in solids, dielectrics, surface states and surface fields in crystals. Prerequisite: one course in linear algebra and one course in quantum mechanics. Klier

445. Elements of Physical Chemistry (4) fall
Quantum chemistry of simple systems, molecular structure and spectroscopy, statistical and classical thermodynamics, and principles of kinetic processes. Lovejoy, Sturm, Zeroka

447. (Biol 447) Experimental Molecular Biology (3)
A survey of current research in molecular biology.

451. Theoretical Organic Chemistry (3) alternate years
Advanced theoretical and mechanistic organic chemistry with emphasis on molecular orbital and group theoretical treatments of structure, spectra, and reactivity of pi-electron systems. Typical applications include conservation of orbital symmetry in pericyclic reactions, and studies of electrophilic, nucleophilic, and homolytic substitution reactions of aromatic compounds. Young

453. Heterocyclic Compounds (3) alternate years
An intensive study of the syntheses, reactions and properties of heteroaromatic compounds including derivatives of thiophene, pyrrole, furan, indole, pyridine, quinoline, the azoles and the diazines; all considered from the viewpoint of modern theories of structure and reaction mechanisms. Prerequisite: Chem 358. Young

458. Topics in Organic Chemistry (1-3)
An intensive study of limited areas in organic chemistry. May be repeated when a different topic is offered. Young, Heindel, Schray

466. Advanced Organic Preparations (2-3)
A laboratory course of instruction in advanced techniques of the preparation of organic compounds.

475. Advanced Topics in Chemistry (1)
Audiovisual courses in topics such as acid-base theory, NMR interpretation; course material obtained from the American Chemical Society. May be repeated for credit. Staff

476. Microbial Biochemistry (3)
Composition, nutrition and metabolism of micro-organisms, with emphasis on microbial enzyme reactions and products of microbial metabolism. Prerequisites: Chem 372 or equivalent. Merkel

477. Topics in Biochemistry (1-3)
Selected areas of biochemistry, such as mechanisms of enzyme action, new developments in the chemistry of lipids, nucleic acids, carbohydrates and proteins. May be repeated for credit when different topics are offered. Prerequisite: consent of the department chairman. Schaffer, Merkel

479. Biochemical Techniques (1-3)
Laboratory studies of the techniques and principles involved in

the isolation, identification and biochemical transformation of carbohydrates, lipids, nucleic acids and proteins. Prerequisite: Chem 371 or its equivalent, previously or concurrently. Merkel, Schaffer

480. Advanced Biochemical Preparations (1-3)
An advanced laboratory course in the preparation, isolation, purification and identification of biochemically produced materials. Emphasis is placed on materials and procedures of current interest in biochemistry. Prerequisite: consent of the department chairman. Merkel, Schaffer

481. Chemistry Seminar (1-6) fall-spring
Reports and discussions of recent developments in chemistry.

482. (ChE, Met 482) Engineering Behavior of Polymers (3) spring
Mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analogs. Topics include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizers, moisture and aging on mechanical behavior. Robinson

483. (ChE 483) Emulsion Polymers (3) fall
Fundamental concepts important in manufacture, characterization, and application of polymer latexes. Topics include colloidal stability, polymerization mechanisms and kinetics, reactor design, characterization of particle surfaces, latex rheology, morphology considerations, polymerization with functional groups, film formation, and various application problems. Prerequisite: previous course in polymers. Vanderhoff

484. (ChE, Met 484) Crystalline Polymers (3) spring
Morphology and behavior of both polymer single crystals and bulk crystallized systems. Relationship between basic crystal physics, thermal and annealing history, orientation and resulting properties. Thermodynamics and kinetics of transition phenomena and a brief treatment of hydrodynamic properties and their relationship to crystallization and processing properties. McHugh

485. (ChE, Met 485) Polymer Blends and Composites (3) fall
Synthesis, morphology, and mechanical behavior of polymer blends and composites. Mechanical blends, block and graft copolymers, interpenetrating polymer networks, polymer impregnated solids and fiber and particulate-reinforced polymers are emphasized. Prerequisite: any introductory course in polymers. Manson, Sperling

487. Topics in Colloid and Surface Chemistry (3)
Applications of colloid chemistry; special topics in surface chemistry. Lectures and seminar. Prerequisite: Chem 397. May be repeated for credit as different topics are covered. Fowkes, Micale, Vanderhoff, Zettlemoyer

488. Advanced Topics in Physical Chemistry (1-3)
Advanced topics in physical chemistry, such as photochemistry and radiation chemistry, Fourier transform spectroscopy, kinetics of rapid reactions, theory of magnetic resonance. May be repeated for credit when different topics are offered.

492. (ChE 492) Topics in Polymer Science (3)
Intensive study of topics selected from areas of current research interest such as morphology and mechanical behavior, thermodynamics and kinetics of crystallization, new analytical techniques, molecular weight distribution, non-Newtonian flow behavior, second-order transition phenomena, novel polymer structures. Credit above three hours is granted only when different material is covered. Prerequisite: Chem 392 or equivalent.

494. Quantum Chemistry (3) alternate years
Principles and applications of quantum mechanics to chemical problems. Applications to chemical bonding, molecular structure, reactivity and spectroscopy. Prerequisite: Chem 415 or consent of the department chairman. Zeroka

495. Statistical Thermodynamics (3) alternate years
Principles and applications of statistical mechanics to chemical problems. A study of the techniques for evaluating the properties of matter in bulk from the properties of molecules and their interactions. Prerequisite: Chem 445 or consent of the department chairman. Zeroka

Civil Engineering

Professors. David A. VanHorn, Ph.D., *chairman*; Lynn S. Beedle, Ph.D., director, Fritz Engineering Laboratory; J. Hartley Daniels, Ph.D.; George C. Driscoll, Ph.D.; Hsai-Yang Fang, Ph.D.; John W. Fisher, Ph.D.; Ti Huang, Ph.D.; Robert L. Johnson, Ph.D.; Celal N. Kostem, Ph.D.; John O. Liebig, Jr., M.S.; Le-Wu Lu, Ph.D.; Alexis Ostapenko, Ph.D.; Adrian F. Richards, Ph.D.; Roger G. Slutter, Ph.D.; Lambert Tall, Ph.D.; Ben-Tseng Yen, Ph.D.
Associate professors. Arthur W. Brune, Ph.D.; George A. Dinsmore, M.S.; Willard A. Murray, Ph.D.; Paul J. Usinowicz, Ph.D.
Assistant professor. Richard N. Weisman, Ph.D.

Profession and Program

Civil engineering, the stem from which has branched the other types of engineering, is concerned with projects which contribute to the comfort and needs of the human race.

The professional practice of a civil engineer includes the conception, design, construction, operation, and maintenance of private and public projects, including bridges, buildings, highways, airports, railroads, harbors, docks, subways, tunnels, water supply and purification systems, sewage collection and treatment facilities, water power developments, the making of surveys, and research. Many civil engineers are associated with consulting engineering firms, contractors, industrial concerns, or various governmental agencies.

In the undergraduate program, the work of the first two years deals chiefly with the scientific and mathematical principles which form the bases of engineering practice. The last two years include the applications of these principles, along with opportunities for elective courses in areas of individual interest. All students receive instruction in engineering measurements, soil mechanics, fluid mechanics and hydraulics, structural theory and design, and transportation and environmental engineering.

Engineers, through their professional societies, have urged that the engineering student be educated as a professional person with a sound understanding of one's place in society. This education is provided through a well-planned civil engineering program enriched by humanistic-social courses selected with the advice and approval of the curriculum director.

For students interested in geological engineering, a five-year program has been developed, leading to two bachelor of science degrees, in civil engineering and in geological sciences. The program is outlined in Section IV.

Recommended Sequence of Courses

freshman year (see page 43)

sophomore year, first semester (15 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
Mech 1	Statics (3)
CE 9	Civil Engineering Computations (1)
CE 11	Engineering Graphics (2)

sophomore year, second semester (16 credit hours)

Math	Elective (3)
CE 40	Surveying Principles I (3)
Eco 1	Economics (4)
Mech 11	Mechanics of Materials (3)
Met 92	Structure and Properties of Materials (3)

summer (3 credit hours)
CE 41 Surveying Principles II (3)

junior year, first semester (17 credit hours)
CE 109 Numerical Techniques (2)
CE 121 Mechanics of Fluids (3)
CE 159 Structural Analysis I (3)
CE 143 Soil Mechanics (3)
General Studies requirement (3)
engineering science elective (3)

junior year, second semester (15-18 credit hours)
Mech 104 Dynamics and Vibrations (3)
CE 170 Environmental Engineering I (3)
CE 160 Structural Design (3)
CE 222 Hydraulic Engineering (3)
General Studies requirement (3)
elective (0-3)*

summer
CE 100 Industrial Employment

senior year, first semester (15-18 credit hours)
CE 203 Professional Development (3)
CE 207 Transportation Engineering (3)
CE 200 Engineering Planning (3)
General Studies requirement (3)
elective (3-6)*

senior year, second semester (15-18 credit hours)
General Studies requirement (3)
engineering science elective (3)
engineering design elective (3)
elective (6-9)*

*Please refer to description of normal program, page 43.

Elective opportunities total 18 to 27 credits, with at least six credits to be in engineering science courses and at least three in engineering design. Lists of appropriate engineering science and engineering design courses are available in the offices of the civil engineering department.

Undergraduate Courses

9. Civil Engineering Computations (1) fall
Applications of computer concepts to civil engineering problems. Prerequisite: Engr 1 or equivalent computer coverage.

11. Engineering Graphics (2) fall
Use of drawing instruments; freehand lettering and shape description; theory of orthographic projection, revolution, and pictorial representation; theoretical problems in space relationships between points, lines and planes; surfaces as loci. Emphasis on visualization and geometric logic. Dinsmore

40. Surveying Principles I (3) spring
Study of the sources, magnitude, effects and removal of systematic errors and reduction of random errors in linear and angular measurements; effect of errors on computations. Care of and field techniques with the steel tape, engineers transit and engineers level. Study of linear measurements, differential leveling, direction of lines, the compass, angular measurements, transverse surveys and calculations; stadia, topographic surveys, horizontal and vertical curves. Field and office work. Liebig, Slutter

41. Surveying Principles II (3) summer
Field astronomy including office procedures to obtain latitude and true direction from observation on the sun and Polaris. Land, topographic, and engineering surveys, including map compilation and drawing of plan, profile, and cross-sections; coordinate systems, earth work, compound, spiral and parabolic curves. Daily recitations and field work for a three-week period. Prerequisite: CE 40. Liebig, Slutter

100. Summer Employment
During the summer following the junior year, students spend at least eight weeks in practical work, preferably in the field which the individual plans to enter after graduation. A written report on the experience obtained is due on return from summer vacation. Prerequisite: senior standing.

104. Readings in Civil Engineering (1-3)
Study of selected technical papers, with abstracts and reports. Prerequisite: consent of the department chairman.

106. Structural Design (3) spring
Elementary theory and design of structures in steel, wood, and concrete. An abridged course in stress analysis and design for students other than civil engineers. Prerequisite: Mech 11.

109. Numerical Techniques (2) fall
Computerized solution of civil engineering problems, predicated on numerical techniques. Prerequisite: CE 9.

121. Mechanics of Fluids (3) fall
Fluid properties and statics; concepts and basic equations for fluid dynamics. Forces caused by flowing fluids and energy required to transport fluids. Dynamic similitude and modeling of fluid flows. Includes laboratory experiments to demonstrate basic concepts. Prerequisite: Mech 1.

123. Fluid Mechanics Laboratory (1) spring
Exercises in pipe flow, open-channel flow, and hydraulic machinery, demonstrating basic principles. Prerequisite: CE 121 or ME 231.

143. Soil Mechanics (3) fall
Fundamental physical, chemical and mechanical properties affecting the engineering behavior of soils. Identification; classification; permeability; effective stress and pore water pressures; compaction, compression and consolidation; stress-strain behavior and shear strength; laboratory tests for engineering properties; application of theories and principles in engineering practice. Prerequisite: Mech 11 or consent of the department chairman.

157. Concrete Laboratory (1) fall
Principles of the behavior of plain and reinforced concrete. Design and preparation of concrete mixtures, and tests of aggregates, control cylinders, and reinforced concrete beams. Prerequisite: CE 160 previously or concurrently.

159. Structural Analysis I (3) fall
Elastic analysis of statically determinate frames and trusses; deflections by the method of virtual work and moment area; force method analysis of indeterminate structures; moment distribution concept. Prerequisite: Mech 11.

160. Structural Design (3) spring
Principles of structural design. Safety and economy. Strength, stability and serviceability criteria. Selection of simple structural members to resist tensile, compressive, bending, and shearing loads. Various structural materials will be covered, especially steel and reinforced concrete. Prerequisite: CE 159.

170. Environmental Engineering Flow Systems (3) spring
Quantitative analysis of water sources. Analysis and design of transmission and distribution of water; collection of wastewater and stormwater. Demonstration laboratories for water and wastewater treatment processes. Prerequisites: Chem 21 and CE 121.

200. Engineering Planning (3) fall
Principles of systems planning of civil engineering projects. A study of factors affecting the inception, evaluation, planning, design and completion of typical engineering projects, including technical, political, economic, social and environmental factors; urban planning; plan implementation; decision-making; management techniques and reporting; optimal principles. Prerequisite: senior standing. Daniels, Dinsmore

203. Professional Development (3) fall
Elements of professionalism; professional ethics; engineering registration; continuing education; responsibilities of an engineer in industry, government, private practice; role of professional and technical societies, management and law in engineering; patents, unions. Prerequisite: consent of the department chairman. Liebig

205. Design Problems (1-6)
Supervised individual design problems, with report. Prerequisite: consent of the department chairman.

207. Transportation Engineering I (3) fall
Principles of the design of transportation facilities with emphasis on highways and airports in the areas of geometric, drainage, and pavement design. Design problems. Prerequisites: CE 41 and senior standing. Liebig, Slutter

211. Research Problems (1-6)
Supervised individual research problems, with report. Prerequisite: consent of the department chairman.

222. Hydraulic Engineering (3) spring
Flow measurements, pipe hydraulics, open-channel flow and river engineering, hydraulic structures and model studies. Laboratory experiments in applied hydraulics. Prerequisite: CE 121.

244. Foundation Engineering (3) spring
Application of the theories and principles of soil mechanics to foundation design. Site investigations and engineering tests to evaluate subsoil conditions. Bearing capacity and settlement analyses for building foundations. Lateral loads on retaining walls and bulkheads. Slope stability and embankment design. Prerequisite: CE 143 or consent of the department chairman. Fang

259. Structural Analysis II (3) spring
Analysis of statically indeterminate structures; methods of slope deflection and moment distribution; consideration of side-sway and nonprismatic members. Influence lines for determinate and indeterminate structures. Flexibility and stiffness matrix methods for computerized analysis. Use of computer library programs. Prerequisite: CE 159.

261. Structural Steel Design (3) fall
Design of steel structures, including plate girders, other built-up members, trusses, frames, grillages, shell-type structures and thin-gage members. Additional topics include connections, composite beams, and fatigue and fracture concepts related to structural design. Prerequisite: CE 160. Tall

263. Structural Concrete Design (3) fall
Design of reinforced concrete structural elements and basic systems, including continuous beams, frames, slabs, footings, and walls. Serviceability criteria. Introduction to prestressing and torsion. Prerequisite: CE 160. VanHorn, Daniels

271. Water and Wastewater Processes (3) fall
Introduction to unit operations and unit processes involved in water and wastewater treatment facilities. Consideration of combinations to meet water quality requirements, either as water supply source or as receiving mantle. Prerequisite: CE 170.

280. Internship (3)
Individual opportunities for qualified advanced civil engineering students to obtain practical experience through association with civil engineers, architects and planners. Typical fields of practice include transportation, hydraulic engineering, environmental engineering, air pollution, regional and city planning, architectural planning, and public works engineering. Prerequisite: senior standing. May be repeated once for credit.

300. Apprentice Teaching CE (1-3)
See the first page of this section.

309. Computer Programming (2) fall
Advanced concepts of Fortran programming in analysis and design. Emphasis on logical program requirements for proper and efficient execution. Addressing and dynamic core allocation. Use of compiler maps and loader maps. Prerequisite: CE 109 or consent of the department chairman.

316. Civil Engineering Planning (3)
Project-oriented planning of one or two civil engineering projects of the students' choice, with oral and written report; task force approach, collection and analysis of data; consideration of technical and environmental factors; cost analyses. Interaction with consulting engineers and planners. Prerequisite: senior standing or consent of the department chairman.

322. Hydromechanics (3)
Ideal fluid flow, vortex flow, creeping motion; laminar boundary layers, turbulent shearing stress and turbulent boundary layers; turbulent jets and diffusion. Prerequisites: Math 205, CE 222.

323. Hydraulic Engineering Laboratory (3)
Laboratory experimentation on applied hydraulics, including hydraulic machinery, hydraulic modeling, flow measurement, and various hydraulics phenomena. Prequisite: CE 222.

324. (Mech 323) Fluid Mechanics of the Ocean and Atmosphere (3)
Hydrostatics of the ocean and atmosphere. Vertical stability. Fluid motion in a rotating coordinate system. Geostrophic flow; ocean currents; surface and internal waves. Prerequisite: ME 231 or CE 121. Macpherson

325. Hydrology (3) fall
Hydrologic cycle. Precipitation, evaporation, transpiration, infiltration. Ground water. Stream flow, hydrographs, floods. Statistical analysis applied to hydrology. Prerequisite: CE 222.

326. Ground Water Hydrology (3) spring
The study of subsurface water, its environment and distribution. Theory of ground water movement. Mechanics of well flow. Sea water intrusion. Artificial recharge. Basin development. Prerequisite: CE 222.

328. Open Channel Hydraulics (3) fall
Energy and momentum concepts, frictional resistance. Rapidly varied flow, gradually varied flow, river controls and channel structures. Prerequisite: CE 222.

332. Ocean Engineering (3) spring
Quantitative oceanographic information for engineers, with emphasis on the coastal zone. Navigation and energy systems; materials; pollution problems; brief survey of the offshore petroleum and mining industries; manned and telechiric undersea operations. Prerequisite: consent of the department chairman. Richards

333. Ocean Engineering Field Investigations (1-3) summer
Field studies in ocean engineering involving participation in research investigations conducted at sea. Prerequisite: consent of the department chairman. Richards, Hirst

341. Soil Stabilization (3) spring
The mechanisms of soil stabilization: compaction, use of additives (aggregates, cement, asphalt, chemicals), special techniques. Principles and techniques of soil stabilization for use as foundation material in highways and airfields; theories of flexible and rigid pavement designs and reinforced earth techniques. Prerequisite: CE 143 or equivalent.

342. Experimental Soil Mechanics (3) fall
Experimental studies dealing with the measurement of soil properties in the laboratory and *in situ*; application of these properties to design; consolidation; strength of soils in triaxial compression and other shear tests, including measurement of pore water pressures; model design and analysis; field measurement of in situ soil properties; laboratory and field instrumentation. Prerequisites: CE 143 and senior standing. Fang

343. Seepage and Earth Structures (3) spring
Long- and short-term stability of embankments and cut slopes; numerical and graphical methods of stability analysis; seepage through soils; design of earth dams, embankments and excavations; influence of embankment stability; construction control, field measurement of pore pressures and earth movements; model studies. Prerequisite: CE 143 or equivalent. Fang

352. Structural Dynamics (3)
Analysis of linear structural systems to time-dependent loads. Free and forced vibration. Classical and numerical methods of solution. Lumped-mass techniques, energy methods, and introduction to matrix formulation of dynamic problems. Application to design. Prerequisite: Math 205, CE 259 or equivalent. Yen

359. Plastic Analysis and Design (3) spring
Plastic analysis and design of steel structures. Strength and behavior of frames and component parts beyond the elastic limit. Methods of predicting strength and deformation in the plastic range. Studies of industrial and multistory frames. Comparison of

plastic design techniques with allowable-stress design methods. Current research. Prerequisite: CE 259 or equivalent.

360. Advanced Structural Design (3) spring
Project-oriented advanced design of structures for bridges and buildings in steel or reinforced concrete and combinations of both materials. Emphasis on economy, strength and performance. Consideration of design of timber or glued-laminated structures, depending on student interest. Prerequisites: CE 261 and CE 263 or equivalent.

365. Prestressed Concrete (3) spring
Principles of prestressing. Analysis and design of basic flexural members. Instantaneous and time-dependent properties of materials. Prestress losses. Additional topics may include continuity, partial prestressing, compression members, circular prestressing, etc. Prerequisites: CE 263; CE 259 previously or concurrently, or consent of the department chairman. Huang, Van Horn

371. Environmental Health Engineering (3) spring
Engineering applications to public health; food and milk sanitation, solid wastes, vector control, communicable disease control. Institutional and industrial sanitation, housing, air pollution, bathing and recreational water quality. Prerequisite: senior standing. Johnson

374. Sanitary Engineering Analysis and Operations (3) spring
Applications of chemical theory, concepts of operations commonly used in water quality control; laboratory evaluations for design of processes in water and wastewater treatment. Prerequisite: CE 271.

376. Water Resources Engineering (3) fall
Utilization of principles of hydraulics, hydrology and environmental engineering in problems of erosion and flood control, power, irrigation, navigation, and water quality control; economics and water law in river basin planning. Prerequisites: CE 222 and CE 170.

380. Design Projects (1-6) fall-spring
Design project work as a member of a team, probably including students from differing disciplines. The project attacks a situation which, when possible, relates to a problem of one of the local communities or industries. Specific projects are normally guided by faculty from several departments with consultants from off-campus. May be repeated for credit. Prerequisite: consent of the department chairman.

381. Special Topics (1-3
A study of selected topics in civil engineering, not included in other formal courses.

385. Research Procedures Seminar (1) spring
Planning and execution of research projects, survey of current research, elements of proposals and budgets. Literature search procedures. Presentation of data, and of written and oral reports. Guidelines for visual aids. Beedle

Graduate Programs

Graduate studies in civil engineering permit the student to build upon the broad background of undergraduate education in order to prepare for professional practice at an advanced level, for research and development, or for teaching.

The selection of graduate courses and research opportunities offered in the department permits the development of study programs either encompassing a wide range of interests or pursuing a special area of civil engineering in depth. The department offers advanced work in structural engineering, geotechnical engineering, geotechnical ocean-engineering, hydraulic engineering and environmental engineering, leading to the master of science, master of engineering and doctor of philosophy degrees.

A graduate program leading to the master of science degree normally consists of a number of courses in a major area, plus at least two courses in a minor area or areas. Each candidate for the master of science degree is required to submit a thesis representing three to six credits (CE 491), or alternately, a report based on a research course of at least three credits (CE 429, 439, 449, 469, 479 or 481); however, a minimum of twenty-four credits in the program should consist of courses outside this group.

A graduate program leading to the master of engineering degree stresses engineering applications and design. The courses may extend across the various specialty areas in civil engineering. Each candidate for the master of engineering degree is required to complete an engineering project representing three to six credits (CE 460) in place of the thesis or research report required for the master of science degree.

A number of selected subjects offered by the departments of mechanical engineering and mechanics, chemical engineering, metallurgy and materials engineering, biology, and geological sciences also may be considered a part of the major field in civil engineering. A list of such subjects is available through the department chairman.

The doctor of philosophy degree program normally includes courses in the major field; courses in minor fields; and a dissertation presenting results of original research. In addition, each candidate is required to have some education in one or two non-engineering fields. This requirement may be met by taking two courses (200 level or above), or by taking two foreign language courses, or by passing a language proficiency examination. Holders of master's degrees planning to become candidates for a doctor of philosophy degree take a qualifying examination at the first opportunity following one semester in residence. After qualification, the program of work is formulated by the candidate, the special committee, and the department chairman.

The laboratories of the department are located in Fritz Engineering Laboratory. Established in 1909 by the generosity of the late John Fritz, and improved through additions to apparatus and equipment, the laboratory offers complete facilities for research and instruction in structural engineering, geotechnical engineering, fluid mechanics, environmental engineering, and related fields.

Structural testing equipment includes dynamic testing machines, a five-million pound universal hydraulic testing machine, and other special loading apparatus. Hydraulic testing equipment includes a dredge pump test facility, plus installations for testing models of spillways, open channels, and beach facilities. A brochure describing the research facilities and programs is available on request.

An interdisciplinary relationship with the Center for Marine and Environmental Studies enables the development of academic and research programs in ocean engineering.

A number of research assistantships and teaching assistantships are available to provide financial aid to students of outstanding promise. The half-time research or teaching duties required of holders of assistantships provide valuable training which supplements the formal course offering. The graduate course offering of the department is programmed to fit the schedule of half-time assistants. A limited number of scholarships and fellowships are available to provide financial aid for full-time study.

Graduate Courses in Civil Engineering

403. Analytical Methods in Civil Engineering (3) fall
Analytical and numerical methods used in various fields of civil engineering. Matrix algebra in engineering analysis. Iterative, differencing, and discretization techniques. Energy principles and special methods. Treatment of typical differential equations in civil engineering. Introduction to theory of elasticity with some engineering applications. Prerequisite: Math 205 or equivalent. Ostapenko

408. Computer Methods in Civil Engineering (3)
Numerical and computer-oriented methods specially applicable to the solution of complex problems arising in various fields of civil engineering. Solutions of well- and ill-conditioned linear and nonlinear systems. Eigenvalue formulation of stability and dynamic problems. Reduction techniques, applied linear graph theory, integration schemes for large structural systems. Optimal design by linear programming. Introduction to problem-oriented languages and computerized design. Prerequisites: CE 403 or equivalent, and working knowledge of Fortran IV programming. Kostem

409. Finite Element Method in Structural Mechanics (3) spring
Basic principles and equations governing the finite element method. Analysis of planar, axisymmetric, plate and articulated structures, with emphasis on analytical modeling. Accuracy and convergence studies, utilizing different discretizations and various types of elements. Case studies include application and extension to material nonlinearities, bridges, containment vessels, and soil-structure interaction. Prerequisites: CE 403, CE 450, or equivalents; working knowledge of Fortran. Kostem

424. Surface Water Hydrology (3) spring
The study of quantities in the flow of water in streams. Hydrographs. Application of statistical analysis and probability to hydrological problems. Drainage basin analysis. Prerequisite: CE 325 or equivalent.

425. Hydraulics of Sediment Transport (3)
Hydrodynamic forces on particles, settling velocity. Sediment transport in open channel: tractive force theory, bed load and suspension theory, total load and wash load. Bedform mechanics, cohesive channel hydraulics. Sediment transport in closed conduits. Shore processes and coastline hydraulics. Prerequisites: CE 121 and CE 222, and consent of the department chairman.

428. Advanced Topics in Hydraulics (1-3)
Recent developments in hydromechanics and hydraulics. Topics to be selected from: wave mechanics, theory of flow through porous media, dispersion, hydrodynamic forces on structures, potential flow, free streamline theory, open channel hydraulics, computer methods. Prerequisites: CE 322 and consent of the department chairman. May be repeated for credit.

429. Hydraulic Research (1-6)
Individual research problems with reports. May be repeated for credit.

431. Geotechnical Ocean Engineering (3)
Study of the engineering and scientific aspects of soils flooring the oceans; soils and their distribution; theory and practice of sampling, laboratory and *in situ* testing, geophysical methods, and computerized data synthesis; biological, geochemical, and physical properties of the electrolyte-gas-solid soil system of the sea floor and the response of this system to applied static and dynamic forces. Prerequisite: CE 143 or equivalent. Richards

437. Advanced Topics in Geotechnical Ocean Engineering (1-3)
Advanced study of selected topics in geotechnical ocean engineering, such as: physico-chemistry of ocean sediments; foundation design in soft sediments; instrumentation for deep-sea soil surveys. Selection of topics will depend on particular qualifications of the staff, as well as interest of students. Prerequisite: consent of the department chairman. May be repeated for credit.

439. Ocean Engineering Research (1-6)
Individual research with reports. May be repeated for credit.

443. Advanced Soil Mechanics I (3) fall
The origin, composition, and physico-chemical properties of soils and their influence on the engineering properties and behavior of soils; transmission of water in saturated and unsaturated soils; advanced theory of compaction; compression and consolidation; theories of shear strength. Prerequisite: a course in soil mechanics.

444. Advanced Soil Mechanics II (3) spring
Fundamental and advanced theories of soil mechanics applicable to earth structures and foundation design; stresses in homogeneous and layered systems for ideal elastic, plastic and visco-elastic soils; lateral earth pressures; slope stability; vibration and other dynamic forces. Prerequisite: CE 443. Fang

445. Advanced Foundation Engineering (3) fall
Current theory and practice relating to the design of foundations for buildings and other structures. Analysis and limitation of settlements; bearing capacity analyses of shallow foundations and piles; flexible and rigid retaining wall design; embankment design; control of seepage and other construction problems; site investigations. Prerequisite: a course in soil mechanics. Fang

447. Advanced Topics in Geotechnical Engineering (1-3)
Advanced studies in selected subjects related to geotechnical engineering. The general areas in which studies may be taken include: stress-strain-time relationships of soils, colloidal phenomena in soils, ground water flow and seepage, soil dynamics, soil plasticity, numerical methods applied to soil mechanics, earth dam design, theories of layered systems and their application to pavement design, rock mechanics. The studies specifically undertaken in any particular semester depend on the availability of staff and the interest of students. Prerequisite: consent of the department chairman. May be repeated for credit.

449. Geotechnical Research (1-6)
Individual research problems relating to soil engineering, with report. Prerequisite: a course in soil mechanics.

450. Advanced Structural Theory I (3) fall
Statical and geometrical stability and degree of statical indeterminacy. Application of energy methods such as virtual work, minimum total potential, minimum complementary energy, and Castigliano's theorems. Introduction to force and displacement matrix analysis of structures. Daniels

451. Advanced Structural Theory II (3) spring
Specialized methods of analysis: column analogy, moment distribution. General treatment of deformation methods using matrix algebra. Selected topics in structural theory: influence lines, multi-story building frames, space structures. Introduction to finite element method; nonlinear problems. Prerequisite: CE 450. Driscoll

453. Structural Members and Frames (3) fall
General torsion of thin-walled open, closed, and combined open and closed cross-sections; general instability of thin-walled members; inelastic instability; special problems in stability. Desirable preparation: Mech 415. Prerequisites: CE 403 and consent of the department chairman. Lu

454. Plate and Shell Structures (3)
Plates and slabs loaded transversely and in their plane. Buckling and postbuckling behavior of elastic and inelastic plates. Membrane and bending analysis of cylindrical, rotational, and hyperbolic-paraboloidal shells. Emphasis on engineering methods. Design considerations. Prerequisites: CE 403 and consent of the department chairman. Ostapenko

455. Advanced Structural Dynamics (3)
Analysis and design of structures to resist wind, earthquake, and blast loading. Matrix methods and computer applications. Nonlinear and elasto-plastic response. Damping characteristics of structures and structural components, spectral analysis, dynamic instability. Characteristics of aerodynamic and seismic forces and nuclear blast. Introduction to vibration of three-dimensional structural systems. Prerequisites: CE 403, CE 352 or Mech 406, and CE 450 or equivalent. Kostem

457. Theory and Design of Steel Structures (3) spring
Analysis and design of steel structures; structural connections; composite steel-concrete systems and other components. Consideration of residual stress; brittle fracture; fatigue strength; fastener systems. Study of current research and application to design practice. Fisher

459. Advanced Topics in Plastic Theory (3) fall
Fundamentals of the mathematical theory of plasticity; the general theorems of limit analysis and their applications to beams under combined loading, arches, space frames, plates and shells. Limit analysis of two- and three-dimensional problems in soil, concrete, rock, and metal. Current developments. Prerequisite: CE 359.

460. Civil Engineering Project (1-6)
An intensive study of one or more areas of civil engineering, with emphasis on engineering design and applications. A written report is required. May be repeated for credit.

462. Experimental Methods of Structural Analysis (3)
Analysis of structures using experimental techniques; use of mechanical devices in study of temperature deformations, foundation displacements, and integral action of structures; moire fringe method; theory of similitude with application to model design; structural analogies. Lu

463. Experimental Methods of Structural Research (3)
Mechanical properties of structural materials and different procedures of evaluating these properties; experimental methods of stress analysis; statistical analysis of experimental data. Yen

464. (Mech 416) Analysis of Plates and Shells (3) fall '79, spring '81
Bending of rectangular and circular plates, plates under lateral loads, plates with thermal and inelastic strains, effect of in-plane forces, large deflections, buckling of plates. Geometry and governing equations of shells, shells of revolution, membrane states, edge solutions, solution by numerical integration, nonsymmetric problems, buckling of shells, applications to pressure vessels. Prerequisites: Math 205; Mech 305, or equivalent course in advanced mechanics of materials. Kalnins, Updike

465. Advanced Topics in Concrete Structures (3) fall
Advanced topics in reinforced and prestressed concrete. Limit design concepts. Yield line theory for concrete slabs. Composite members. Additional topics may include design of concrete bridge systems, shear walls, arches; seismic design. Prerequisite: CE 263 or equivalent. Huang, VanHorn

466. Concrete Shell Structures (3)
Analysis and design of concrete shell structures. Folded plates, cylindrical shells, and shells of double curvature. Typical practical problems. Prerequisites: CE 403 and consent of the department chairman. Ostapenko

467. Advanced Topics in Structural Engineering (1-3)
Advanced study of selected topics in structural mechanics and engineering, such as: finite element methods, suspension systems; space frames; stability of nonlinear systems; coldformed and lightweight construction; optimization and reliability; second-order phenomena in structures; interaction of structures with the environment; structural use of plastics; composite construction, etc. Selection of topics will depend on particular qualifications of the staff, as well as on the interests of the students. Prerequisite: consent of the department chairman. May be repeated for credit.

468. (Mech 415) Stability of Elastic Structures (3)
Basic concepts of instability of a structure; bifurcation, energy increment, snap-through, dynamic instability. Analytical and numerical methods of finding buckling loads of columns. Postbuckling deformations of cantilever column. Dynamic buckling with nonconservative forces. Effects of initial imperfections. Inelastic buckling. Buckling by torsion and flexure. Variational methods. Buckling of frames. Instability problems of thin plates and shells. Prerequisite: Math 205. Kalnins

469. Structural Research (1-6)
Individual research with reports. May be repeated for credit.

471. Water Treatment Facilities (3) fall
Theory and design of water treatment facility components, from source to distribution system. Laboratory work in water chemical parameter determinations for design applications. Prerequisite: CE 374. Johnson, Usinowicz

472. Water Pollution Control Facilities (3) spring
Fundamental principles and design of water pollution control facilities for domestic and industrial waste waters. Physical-chemical and biological studies in laboratory determination of design parameters to be applied in design procedures. Prerequisite: CE 374. Johnson, Usinowicz

475. Advanced Topics in Water Resources (1-3)
Advanced study of selected topics in areas such as: physicochemical methods of water quality control; biological systems for waste-water treatment; multiple use of water resources; and others. Selection of topics will depend on particular qualifications of the faculty as well as interest of the students. Prerequisite: consent of the department chairman. May be repeated for credit.

479. Environmental Engineering Research (1-6)
Individual research problems in environmental engineering with summary report. May be repeated for credit.

481. Special Problems (1-6)
An intensive study, with report, of a special field of civil engineering which is not covered in the other courses. A design project or an interdisciplinary study of a problem related to civil engineering may also be included. May be repeated for credit.

483. Graduate Seminar (1-3)
Study of current topics in civil engineering.

491. Thesis (1-6)

Classics

Professors. Edna S. de Angeli, Ph.D., *chairman*; Douglas D. Feaver, Ph.D.
Assistant professor. Charles R. Phillips, III, Ph.D.

The study of classics affords the student a comprehensive view of Greco-Roman culture and its impact on contemporary life and letters. Since classics is by nature interdisciplinary, the student may concentrate in several areas: language, literature, history, philosophy, archaeology, or any combination of these disciplines. Courses in Latin and Ancient Greek leading to proficiency in those languages enable the student to read the masterpieces of Greece and Rome in the original. Other courses taught in English focus on critical appraisal of classical achievement in all aspects, so that perennial themes can be seen in historical perspective.

Classics as a major has stood the test of time, offering a general cultural background for careers in widely diverse fields in the professions, business, and public service. It has particular relevance as a preparation for careers in teaching, law, writing, archaeology, and the church.

Lehigh University is a cooperating institution of the Intercollegiate Center for Classical Studies at Rome and of the American School of Classical Studies at Athens. Lehigh students are eligible for tuition grants at Athens and at Rome.

Note: Courses designated *Clss* are taught in English. No knowledge of Latin or Ancient Greek is required or involved.

Major in Classical Greek

required preliminary courses

Gk 1, 2	Elementary Greek (6)
Gk 3, 4	Intermediate Greek (6)

required major courses

Gk 111, 112	Greek Drama (6)
Gk 113	Greek Historians (3)
Gk 203	Greek Epic (3)
Gk 271	Readings (3)
Gk 316	Plato (3)
Clss 21	Ancient History (3)
Clss 202	Archaeology of Greece (3)
Clss 52	Latin Literature in English Translation (3)

Those majoring in Greek write a translation examination during their seventh semester. No comprehensive examination is required.

Major in Latin

required preliminary courses

Lat 61	Elementary Latin (3)
Lat 62	Elementary Latin (3)
Lat 63	Intermediate Latin (3)
Lat 64	Intermediate Latin (3)

required major courses

Lat 165	Vergil (3)
Lat 166	The Latin Lyric (3)
Lat 168	Latin Drama (3)
Clss 22	Ancient History (3)
Clss 203	Archaeology of Italy (3)
Clss 51	Greek Literature in English Translation

and twelve hours from the following:

Lat 211	Readings (3)
Lat 212	Readings (3)
Lat 213	Ovid (3)
Lat 303	The Roman Epic (3)
Clss 241 (RS 241)	Pagan, Jew and Christian (3)

Those majoring in Latin write a translation examination during their seventh semester. No comprehensive examination is required.

Major in Classics

This major is designed for those planning to go on to graduate work in classics, ancient history, ancient philosophy, classical archaeology, and classical linguistics.

Programs in this major are worked out for each student with due consideration for the individual's particular preparation and specific goals. In general the program will require as a minimum:

eighteen hours of courses in either the Latin or Greek language at the 100 level or higher;
twelve hours of courses in the second language;
six hours in ancient history (Clss 21, 22);
six hours in Senior Seminars (Greek 381, Latin 382).

Depending upon specific goals, the student is strongly urged to take courses in art and architecture, fine arts, medieval history, philosophy, French and German.

Either a comprehensive examination or a senior essay is required for graduation.

Major in Classical Civilization

required preliminary courses (6 credit hours)

Clss 21	Ancient History (Greek) (3)
Clss 22	Ancient History (Roman) (3)

required major courses (24 credit hours in one of the areas of concentration)

Concentration in Archaeology

Clss 201	Archaeology of the Near East (3)
Clss 202	Archaeology of Greece (3)
Clss 203	Archaeology of Italy (3)
Clss 204	The Ancient City (3)
Clss 206	Ancient Technology (may be substituted for Clss 204)
Anth 9	The Anthropological Enterprise (3)
Anth 232 (Clss 232)	Principles of Archaeology and Pre-History (3)

One course chosen from the area of classical literature (3).
One course chosen from the following: Phil 131; RS 111, 114 (3).

Concentration in Classical Literature

Clss 51	Greek Literature in English Translation (3)
Clss 52	Latin Literature in English Translation (3)
Clss 250	Women in Antiquity (3)
Clss 251	Classical Mythology (3)
Gk 203	Greek Epic (3) or
Lat 303	The Roman Epic (3)

One approved course in English or foreign literature at the appropriate level. Any language course, ancient or modern, above the elementary level, may be offered as a substitute.
One course chosen from the area of archaeology (3)
One course chosen from the following: Phil 131; RS 111, 114 (3)
A comprehensive examination or senior essay is required in the area of concentration.

Undergraduate Courses in Greek

1. Elementary Greek (3) UP fall
For all students who desire to obtain a knowledge of the fundamentals of the Greek language. Early in the semester, there is reading in stories and legends in easy Greek.

2. Elementary Greek (3) UP spring
Continued work in Greek vocabulary, forms and syntax. Selected readings in Greek prose. Prerequisite: Gk 1.

3. Intermediate Greek (3) UP fall
Xenophon: *Anabasis* or Herodotus, *Histories*. Grammar review. Prerequisites: Gk. 1 and 2, or one year of entrance Greek.

4. Intermediate Greek (3) UP spring
Plato: *Euthyphro, Apology* and *Crito*, or other dialogues. Prerequisite: Gk 3

51. Greek Literature in English Translation (3) P fall
Readings in major genres of Greek literature; emphasis on development of epic, drama and lyric poetry. No knowledge of the Greek language is required.

111. Greek Drama (3) fall, alternate years
Representative plays of Sophocles, Euripides and Aristophanes. Literary study of the drama. Prerequisite: Gk 4.

112. Greek Drama (3) spring, alternate years
Continuation of Gk. 111. Prerequisite: Gk 4.

113. Greek Historians (3) fall, alternate years
Selections from Herodotus, Thucydides or Xenophon. A study of Greek historiography. Prerequisite: Gk 4.

For Advanced Undergraduates and Graduates

203. Greek Epic (3)
Reading of considerable portions of the Homeric Epics and a study of the poems as works of literature. Studies of the background of the poems, and introduction to scholarly problems of interpretation and theories of origins. Prerequisites: six hours of courses at the 100 level and consent of the department chairman.

271. Readings (3) spring, alternate years
Intensive reading in one author or in a selected genre. Prerequisites: six hours of courses at the 100 level and consent of the department chairman.

316. Plato (3)
The Republic, and other dialogues. Lectures on classical philosophy. Prerequisites: six hours of courses at the 100 level and consent of the department chairman.

381. Senior Seminar (3)
A proseminar: introduction to classical scholarship with particular attention to the methods of research, bibliographical aids and scholarly literature. Surveys are made of such varied fields as archaeology, numismatics, hermeneutics, palaeography and epigraphy. Prerequisite: consent of the department chairman.

Undergraduate Courses in Latin

61. Elementary Latin (3) UP fall
For all students who desire to obtain a knowledge of the fundamentals of the Latin language. Special emphasis on English derivations and the principles of grammar.

62. Elementary Latin (3) UP spring
Continuation of Latin 61. Prerequisite: Latin 61 or two entrance units.

63. Intermediate Latin (3) UP fall
Selections from the easier authors. Grammar review. Prerequisite: Latin 62 or three entrance units.

64. Intermediate Latin (3) UP spring
Selections from representative writers. Review of grammar and syntax. Prerequisite: Latin 63 or consent of the chairman.

165. Vergil (3) UP
Vergil: Aeneid, selections from the entire work; study of the aesthetic, political, and philosophical values of Vergil's poetry. Prerequisite: Latin 64 or consent of the department chairman.

166. The Roman Lyric (3)
Selected poems of Horace and Catullus. Lectures on development of lyric poetry. Introduction to metrics. Prerequisite: Latin 65 or four entrance units.

168. Latin Drama (3) spring
Readings of selected plays of Plautus, Terence and Seneca. Prerequisite: Latin 65 or at least four entrance units.

For Advanced Undergraduates and Graduates

211. Readings (3) fall
Intensive readings in one author or in a selected genre. Prerequisites: six hours of courses at the 100-level and consent of the department chairman.

212. Readings (3) spring
Intensive reading in one author or in a selected genre. Prerequisites: six hours of courses at the 100-level and consent of the department chairman.

213. Ovid (3) fall
The *Metamorphoses* and major elegiac works. Development of courtly love. Prerequisites: six hours of courses at the 100 level or consent of the department chairman.

303. The Roman Epic (3)
The epic in Latin literature with lectures on the Greek models; early Latin translations of Greek epics; later minor writers of epic. Passages from Lucretius, Vergil and Ovid; a study of the *Aeneid* in its entirety. Prerequisites: six hours of courses at the 100 level and consent of the department chairman.

382. Senior Seminar (3)
Continuation of Gk 381. Prerequisite: consent of the chairman.

Classical Civilization (Clss)

Note: The following are undergraduate-level courses.

21. (Hist 21) Ancient History (3) UP fall
The development of civilization from palaeolithic times to the world empire of Alexander the Great. The social, economic, religious, philosophic, artistic and literary development of the ancient world; the origin of political institutions. Phillips

22. (Hist 22) Ancient History (3) UP spring
Continuation of Clss 21. Rome from its origin to 475 A.D. Phillips

51. Greek Literature in English Translation (3) UP fall
Readings in major genres of Greek literature; emphasis on development of epic, drama and lyric poetry. No knowledge of the Greek language is required. de Angeli

52. Latin Literature in English Translation (3) UP spring
Readings in major genres of Latin literature. Emphasis on epic, Roman comedy and satire. No knowledge of the Latin language is required. de Angeli

201. Archaeology of the Near East (3) UP fall, alternate years
Aims and methods of archaeology. A chronological survey of archaeological finds from Palaeolithic, Neolithic, Bronze Age, Iron Age and later cultures in the Near East, concentrating on the Nile, Tigris-Euphrates River basins, and the Levant. Material illustrating the cultures and events of the Bible. Feaver

202. Greek Archaeology (3) UP fall, alternate years
Aims and methods. A chronological presentation of prehistoric civilizations including the Neolithic, Minoan, Helladic and Mycenaean periods. A study of extant ancient monuments, buildings and city plans of important sites of the classical and Hellenistic periods. Lectures, collateral readings and reports. Feaver

203. Archaeology of Italy (3) UP fall, alternate years
Neolithic, Terramara, Villanovan and Etruscan cultures. Rome the city: its buildings, monuments and streets, its destruction and rediscovery through excavation; origin and growth of the city; the three periods, empire, republic and kingdom; methods of identifying and dating monuments. A survey of Pompeii, Herculaneum and Ostia. Lectures, readings and reports. Feaver

204. The Ancient City (3) UP spring, alternate years
Ancient cities seen through concepts of human community and political theory as compared with archaeological findings; ancient theories of city and city-planning; attitudes to life in the city; rise of urban civilization from Neolithic prototypes through the Near East, Egypt, Greece and Rome; insights applicable to current urban problems. Feaver

206. Ancient Technology (3) UP spring
History of tools, technology and technique from the stone ages to beginning of the industrial age; their effects on society. Attitudes to technology, artisans and engineers in ancient mythology, literature, philosophy and religion. Explanations for the divorce of science and technology in antiquity and slow pace of technological advance. Feaver

232. (Anth 232) Principles of Archaeology (3)
Basic methods of prehistoric archaeology, with focus on problems shared with other branches of anthropology. Gatewood

241. (RS 241) Pagan, Jew and Christian (3) UP fall
Examination of religious groups in the Roman Empire as social phenomena. Reactions to historic circumstances. Similarity and divergence of religious experience. Readings in primary sources. Lectures and discussion. Phillips

250. Women in Antiquity (3) UP spring
Status of women in antiquity in light of modern thinking about women's roles in society. Literary evidence for the battle of the sexes in ancient Greece and Rome. Phillips

251. Classical Mythology (3) UP fall
Readings in the major myths and legends of ancient Greece and Rome, with intensive study of those having the greatest relevance for modern man. Changing aspects of myth as reflected in both ancient and modern literature. Psychological and structural approaches to myth. de Angeli

Computing and Information Science

This academic program is associated administratively with the department of mathematics. Therefore, the reader is referred to that entry in this section of the catalog for details of the program and courses.

Economics

Professors. Eli Schwartz, Ph.D., *chairman*; J. Richard Aronson, Ph.D.; Nicholas W. Balabkins, Ph.D.; Alvin Cohen, Ph.D.; Gerald Garb, Ph.D.; Finn B. Jensen, Ph.D., MacFarlane professor; L. Reed Tripp, Ph.D., Magee professor.
Associate professors. Jon T. Innes, Ph.D.; John D. Keefe, M.A.; John R. McNamara, Ph.D.; R. Allen Moran, Ph.D.; Warren A. Pillsbury, Ph.D.; Ching Sheng Shen, Ph.D.; Robert J. Thornton, Ph.D.
Assistant professors. Bruce R. Dalgaard, Ph.D.; John L. Hilley, Ph.D.; Arthur E. King, Ph.D.
Instructor. Todd Behr, M.A.

Though economics is variously defined, modern-day definitions generally suggest that it is the study of the principles that govern the efficient allocation of resources. One of the greatest of the 19th-century economists who did much to uncover these principles suggested a broader definition. Alfred Marshall described economics as "a study of mankind in the ordinary business of life . . . a part of the study of man." This dual nature of economics, tech-

nical and humanistic, is reflected in the fact that at Lehigh the economics major is available to students in the College of Arts and Science as well as in the College of Business and Economics.

As the description below suggests, the economics program is exceptionally flexible once one moves beyond the sophomore year. This flexibility allows the major to be adapted easily to the needs of students with widely varying goals. Although many students choose the economics major in order to secure a firm foundation in economics and finance before entering the business world, still others choose it regularly as preparation for law school or as a complement to their major in government, history, international relations, journalism, mathematics or urban studies. Naturally, many students who major in economics do so with the intent of pursuing graduate work at the master of business administration or doctor of philosophy level; others simply want to become "economically literate" in a world where such literacy is increasingly in demand.

At the same time that the program provides flexibility, it also consists of a substantial core of economic theory and related courses. This assures that the student who is uncertain concerning career goals will obtain a broad education in economics and business no matter what upper-level courses are chosen.

Students who are interested in designing a major program in economics suitable to their needs should consult with the curriculum director or department chairman.

Major in Arts and Science

freshman year

Eco 1	Economics (4)
Math 41 and 44*	BMSS Calculus (6)

*Students who wish to take mathematics beyond calculus should substitute Math 21-23 for this requirement.

sophomore year

Acctg 51	Essentials of Accounting (3)
Eco 45	Statistical Methods (3)
Eco 105	Microeconomic Analysis (3)
Eco 119	Macroeconomic Analysis (3)

junior year

Fin 225	Business Finance (3)
Eco 229	Money and Banking (3)
Eco electives*	any 300-level economics courses (6)

senior year

Eco electives*	any 300-level economics courses (9)

*Upper-level finance courses may be substituted for economics courses with the approval of the curriculum director.

Major in Business and Economics

Required: fifteen credits of economics beyond the core listed on page 42.

Undergraduate Courses in Economics

1. Economics (4) fall-spring
A course in the principles of economics. General topics covered are: the determination of national income; the determination of relative prices; money and banking; monetary and fiscal policy; and government finance.

Economics 1 is a prerequisite for all subsequent courses in economics.

45. Statistical Methods (3) fall-spring
Descriptive statistics, elementary probability and probability distributions, sampling, estimation of population parameters, decision theory, regression and correlation, analysis of variance, nonparametric tests, time series analysis, and index numbers. Prerequisite: Math 41 or equivalent.

105. Microeconomic Analysis (3) fall-spring
Determination of prices in terms of the equilibrium of the business enterprise and consumer choices in markets of varying degrees of competition; determination of wages, rent, interest and profits.

119. Macroeconomic Analysis (3) fall-spring
An introduction to macroeconomic measurement, theory, and policy. Provides framework within which broad macroeconomic policy prescription can be formulated especially with reference to such problems as inflation and unemployment.

For Advanced Undergraduates and Graduate Students

229. Money and Banking (3) fall-spring
A general course dealing with the nature and functions of money and commercial banking, monetary and banking development in the United States, the value of money, and monetary, credit and fiscal policies.

300. Apprentice Teaching in Economics (1-3)
See the introductory pages of this section.

303. Economic Development (3) fall
The principal determinants of economic development; economic development in advanced and underdeveloped countries. Cohen

305. The Economic Development of Latin America (3) spring
Forces at work in the changing economics in Latin America: in addition to the economic variables, social and political factors are considered and related to technological change and the development process. Cohen

309. Comparative Economic Systems (3) fall
A comprehensive examination of the philosophical, economic, and political tenets of American capitalism, Soviet socialism, and Nazi fascism. Analysis of economic planning under various socio-economic systems: study of comparable economic growth of the United States and the Soviet Union. Balabkins

310. Economic Evolution (3) spring 1979 and every other year
Long-term economic growth and social transformation of the United States. Balabkins, Thornton

311. Environmental Economics (3) fall-spring
Economic policies for environmental protection. The optimal development of natural resources. The relationship between economic growth and environmental degradation. Case studies in water-quality management. McNamara

312. Urban Economics (3) spring
A survey and analysis of economic problems related to urban areas; the nature and function of cities; the economic and spatial characteristics of urban activity including housing, land value, land use, transportation, fiscal problems, urban labor markets and poverty. Pillsbury

313. History of Economic Thought (3) fall, even-numbered years
Chronological survey and critical evaluation of the evolution of economic science. Analysis of the contributions of the Classical, Marginalist, Neo-classical, Keynesian, Institutionalist, and Structuralist schools. Cohen

314. Energy Economics (3) spring
The economic theory of resource allocation over time. Economics of exhaustible and renewable natural resources. Energy production, transportation, pricing and consumption. Government regulation of the energy industry. Computer models for energy system forecasting and planning. McNamara

317. Development of American Business (3) fall
An investigation of the development of the American business system, colonial period to the present, including the origins, organization, expansion, adaptation and economic consequences of the corporate economy. Stress is placed on the process, structure and function of the maturing American business as it evolves into the modern, multi-unit business enterprise. Applications of economic analysis to the experience of specific businesses, empirical research and data analysis are emphasized. Dalgaard

320. Advanced Macroeconomic Analysis (3) spring, 1980
A further course in macroeconomic theory and policy. Primary consideration is given to alternative theoretical specifications of monetary economies and the resulting policy implications for achieving economic growth and stability. Prerequisite: Eco 119 or equivalent. Innes

332. Monetary-Fiscal Policy (3) spring
A course devoted to the study of monetary, credit and fiscal policies of governments and central banks with particular reference to the policies of the United States Treasury and the Federal Reserve system. Current problems receive emphasis. Prerequisite: Eco 119 or equivalent. Dalgaard

333. Managerial Economics (3) fall-spring
The fundamental business disciplines are integrated through the development of a model of managerial decision-making. Emphasis on the application of economic theory to a variety of business problems. Consideration is given to problems involving risk and uncertainty. Case studies are employed as illustrative examples.

335. Labor Economics (3) fall-spring
The structure of the labor force; the theory of wages and employment; the economics of legal and social aspects of the labor market. Tripp, Thornton

336. Business and Government (3) fall, odd-numbered years
Microeconomic theory and the American legal system. Efforts by the state to maintain, moderate, and supersede competitive private contracting as a social arrangement by which to promote risk-taking, efficiency, equitable exchange, progressiveness, conservation, and individual liberty. Economic analysis of results. Pillsbury

337. Transportation and Spatial Economics (3) spring, 1980
The principles of transportation in theory and practice are integrated with traditional and spatial economics. Transport models and location theories are reviewed for varying conditions of spatial separation of economic activity. Transportation policies are analyzed and evaluated in terms of their efficiency in the allocation of resources for the firm and the economy at the local, regional and national levels. Prerequisite: Eco 105 or consent of the department chairman. Pillsbury

338. Labor Market Institutions (3) fall
The development of the social and legal status of trade unions; the process of collective bargaining; the evolution of modern social welfare programs. Tripp, Thornton

339. International Trade (3) fall
The theory of international trade; the theory of tariffs; United States commercial policies; the impact of growth and development on the world economy. Jensen

340. (Fin 340) International Finance (3) spring
The balance of payments and the theory of disturbances and adjustment in the international economy; international monetary policies. Prerequisite: Eco 229. Jensen, Hilley

343. European Economic Integration (3) spring, 1979, 1981
Analysis of the problems of economic integration with special emphasis on the development of economic cooperation and integration in Western Europe. The methods and the problems of economic planning in the Common Market. United States trade and investments and European economic integration. Jensen

346. Business Cycles and Forecasting (3) fall, odd-numbered years
A study of economic conditions, involving short-term fluctuations, growth, forecasting and stabilization proposals. Prerequisite: a course in statistics. Moran

348. Advanced Business Cycles (3)
Recent business cycle theories; the evolution of the theories and the problems of economic change which the theories attempt to explain. Prerequisite: Eco 346. Students desiring this course should consult the department chairman.

351. Introduction to Mathematical Economics (3) fall, 1980
Applies mathematical techniques to economic problems of optimization and constrained optimization and to economic models involving both comparative static and dynamic analysis. Prerequisites: Math 41 and 44, Eco 105 and 119. Innes

352. Advanced Statistical Methods (3) spring
A further course in quantitative method: sampling design, probability distributions including the analysis of variance, and multiple correlation and their application to common situations. Prerequisite: Eco 45 or equivalent. Shen

353. (Fin 353) Public Finance: Federal (3) fall
A course dealing with government expenditures and revenues, the economics of taxation, and government administration. Aronson

354. (Fin 354) Public Finance: State and Local (3) spring, 1979, 1981
The major issues regarding revenues, expenditures, debt and budgeting policy are examined in the light of fiscal principles and economic effects. Prerequisite: Eco 353. Aronson

357. Applied Econometrics for Business and Economics (3) fall
This course provides empirical content to concepts developed in intermediate economic theory. Applied problems in construction, evaluation and use of econometric models are included. The student has the opportunity to gain practical experience through research and case studies. Prerequisites: a course in statistics and a course in intermediate economic theory. King

371. Readings in Economics (3)
Readings in various fields of economics, designed for the student who has a special interest in some field of economics not covered by the regularly rostered courses. Prerequisite: preparation in economics acceptable to the department chairman.

372. Readings in Economics (3)
Continuation of Eco 371.

For Graduate Students

404. Development Theory and Problems (3) fall, 1980
The evolution of growth doctrines and the analysis of such developmental problems as: structural versus monetary reform, ideological controversy of the appropriate economic system, balanced investment programs as opposed to unbalanced plans, the nature and changes in the aggregate production function, and dependence upon domestic as opposed to foreign sources of savings. Prerequisite: Eco 303. Cohen

405. Microeconomic Theory (3)
The role of the price mechanism in the allocation of scarce resources among competing uses. Emphasis is placed on the behavior of consumers and firms in various market structures. Attention is given to the pricing of the factors of production, as well as to the analysis of general equilibrium. This course is designed to meet this background requirement of a student enrolled in the master of business administration program.

407. History of Economic Thought (3) spring, 1979, 1981
Consideration of selected topics in the history of economic thought, with special attention devoted to tracing the origins of modern economic theory. Prerequisite: graduate exposure to economic theory. Cohen

411. Economics of Environmental Management (3) fall, 1980
The economic theory of natural resources. Optimal policies for the development of renewable and nonrenewable resources. Pollution, congestion and common property problems. Environmental quality management systems. Prerequisites: Eco 105 or equivalent and Math 44 or equivalent. McNamara

415. (Fin 415) Capital and Interest Theory (3) fall, alt. years
Examination of theories of interest and capital. The following topics are investigated: present value theory; investment valuation under certainty and risk; term structure of interest rates; the theory of savings, cost of capital, and capital formation. Prerequisite: consent of the department chairman. Schwartz

417. Basic Statistics for Business (3)
A first course in statistical analysis dealing with descriptive statistics, probability, and statistical inference in a business context. This course is designed to meet this background requirement of a student enrolled in the master of business administration program.

425. Public Finance (3) spring, even-numbered years
Major issues in taxation of income, consumption, and capital; principles of government debt management; budgeting and fiscal planning for economic stability and growth. Aronson

429. Money, Banking and Monetary Policy (3)
An historical overview of money and banking with emphasis on central banking and monetary and fiscal policy. A study of the functions of financial intermediaries, the value of money, the impact of money on income, output, employment and prices. A review of the application of monetary and fiscal policy to economic problems. This course is designed to meet this background requirement of a student enrolled in the master of business administration program.

431. Managerial Economics (3) fall-spring
Problems of business enterprise: price and output determination analysis of cost and demand functions in markets of various types and under various conditions of general business. Emphasis will be on the application of economic theory to business practice. Prerequisite: Eco 105 or consent of the department chairman. McNamara, Innes

432. Advanced Microeconomic Analysis (3) fall
A survey of methods of decision-making at the microeconomic level utilizing concepts developed in price theory and econometrics. Prerequisite: Eco 105 or equivalent. Garb

435. Advanced Topics in Microeconomics (3) spring, 1979, 1981
Topics in resource allocation and price determination. Theories of choice of consumers, firms, and resource owners under monopoly, monopsony, competition, and alternative market forms. Prerequisites: Eco 432 or equivalent and consent of the department chairman. Garb

436. Advanced Topics in Macroeconomics (3) spring, 1979, 1981
Theory of employment, income, and growth. Role of money in theory of output. Policies for economic stability and growth. Prerequisite: consent of the department chairman. Innes

437. Labor Economics (3) fall
The economic environment of labor and industrial relations with some emphasis on current research involving theoretical and empirical analyses of labor markets. Prerequisite: Eco 335 or 338 or equivalent. Thornton

438. Labor-Management Administration (3) spring
A study of the administration of the relationship between management and the labor force both where that relationship is governed by a formal agreement and where it is not. The concepts underlying the substantive provisions of labor agreements are analyzed. The problem of agreement-making and the methods for peacekeeping are subjected to critical appraisal. Prerequisite: Eco 335 or 338 or equivalent.

440. Regional Science-Metropolitan Analysis (3) fall, 1980
A study of the methodology of regional science with emphasis on metropolitan area analysis. A survey of the applications of this methodology to the economic problems of regions and metropolitan areas. Pillsbury

442. (Fin 442) Foreign Trade Management (3) spring, 1979, 1981
Current problems of foreign operations, including channels of export in foreign markets, export and import financing, foreign investments, policies of government and international agencies as they affect foreign operations. Jensen

444. (Fin 444) Banking and Monetary Policy (3) fall-spring
Description and analysis of the U.S. monetary and banking structure. The supply and demand for funds. Financial markets. Central bank controls; monetary theory and policy. Prerequisite: a course in money and banking. Innes, Schwartz

445. International Economic Theory (3)
The theory of international economics, with emphasis on the way in which general economic theory is applied to the problems and issues of international economics. Prerequisite: consent of the department chairman. Students desiring this course should consult the chairman. Garb

453. Index Numbers and Time Series Analysis (3)
Theory and construction of index numbers. Measurement and analysis of irregular, seasonal, cyclical and secular components. Exponential smoothing, distributed lags, and introduction to spectral analysis. Students desiring this course should consult the department chairman. Shen

454. Forecasting (3) spring, even-numbered years
A study of the methods of business forecasting and its relation to planning with emphasis on the prediction of growth and short-term movements. Prerequisite: Eco 346 or equivalent. Shen

455. Econometric Methods (3) spring, odd-numbered years
Mathematical and statistical specification of economic models. Statistical estimation and test of economic parameters in single and multiple equation models. Prediction and test of structural changes. Prerequisites: background in statistics and calculus. Shen

456. Mathematical Economics (3) fall, odd-numbered years
Designed to provide an understanding of the way in which various mathematical techniques are applied in the formulation and development of economic concepts and theories. The course may draw on theories of the consumer and of the firm, the analysis of economic fluctuations and growth, general equilibrium theory, and other areas of economics where mathematical techniques have been found to be useful. Prerequisite: consent of the department chairman. Garb

461. Methodology in Theory and Research
Foundations of theory construction and empirical research in economics and related subject matter. Theory, hypothesis formation and empirical study in the business firm, organizations, industrial relations, and micro-macro research. Students desiring this course should consult the department chairman. Garb

471. Special Topics (3)
An extended study of an approved topic in the field of economics.

472. Special Topics (3)
Selected topics not covered in scheduled courses in the department. May be repeated for credit with consent of the chairman.

490. Thesis in Economics (6)
Subjects for theses may be selected by consultation with the major adviser and approval of the department chairman and master of arts committee.

School of Education

Perry A. Zirkel, *dean.*

The School of Education is organized into three departments: Administration and Supervision (AdmS), Human Development (HD), and Instruction and Curriculum (I&C). Faculty and course offerings are listed by department. The reader is also referred to the School of Education entry in Section IV.

Department of Administration and Supervision

Professors. Matthew W. Gaffney, Ed.D.; Charles W. Guditus, Ed.D.; Perry A. Zirkel, J.D., Ph.D., dean.
Associate professors. LeRoy J. Tuscher, Ph.D., *chairman.*
Assistant professors. Robert D. Fleischer, Ed.D.; Virginia Wylie, Ph.D.
Adjunct professor. Lawrence Stratton, Ed.D.
Adjunct assistant professors. Raymond Bernabei, Ed.D.; Thomas E. Persing, Ed.D.; Stephen Sivulich, Ed.D.; Nan Van Gieson, Ed.D.

For Advanced Undergraduates and Graduate Students

AdmS 381. Educational Systems and Information Processing (3)
Basic principles of systems analysis, information processing, cost analysis, and conversion systems. Application of computers and data processing to administration and instruction in basic educational institutions.

AdmS 383. Computer-Assisted Instruction (3)
Design and development of computer-assisted instructional units. Students design, program and test computer-assisted instruction as a drill, practice, tutorial, or simulation exercise.

For Graduate Students

AdmS 400. Educational Administration; Theory and Practice (3)
Development of theories of administration and applications in educational institutions. Adminstrative behavior in organizational settings; administrator's leadership role in decision-making, evaluation, and conflict resolution.

AdmS 402. Elementary School Administration (3)
Major problems of organization and administration of elementary schools; types of organization, pupil promotion, time allotment, service agencies, and plant equipment.

AdmS 403. (HD 403, I&C 403) Research (3)
Basic principles of research; techniques of gathering and analyzing data; design of studies in education. Emphasis on critical reviews of research reports representing various methodologies. Research report required.

AdmS 404. Secondary School Administration (3)
Major problems of organization and administration of secondary schools; program of studies, teaching staff, pupil personnel, plant and equipment and community relationships.

AdmS 406. School Principals Clinic (3-6)
Simulated materials workshop on administrative decision-making open to practicing and prospective elementary and secondary school administrators.

AdmS 410. Administration of Higher Education (3)
Analysis of legal foundations, administrative controls, and operational patterns of various types of institutions of higher education.

AdmS 412. Teaching in the Two-Year College (3)
Major theories of teaching, learning, and measurement in the two-year college. Characteristics of students in two-year colleges are examined. Participants undertake research in the field.

AdmS 414. The Two-Year College (3)
Historical and philosophical analysis of the two-year college is considered in relation to service functions and values in American higher education. Participants undertake research in the field.

AdmS 450. (I&C 450) Foundations of Curriculum Construction (3)
Principles of organization of program of studies for elementary and secondary schools; origin and background of the curriculum; methods of organization; curriculum planning and development; pertinent applications. Kindergarten through 12th grade (K-12).

AdmS 452. (I&C 452) The Elementary School Curriculum (3)
Problems of curriculum development in the first six grades; subject matter placement, program making for difficult types of schools, regular vs. special subjects, articulation.

AdmS 454. (I&C 454) The Secondary School Curriculum (3)
Methods of study of curriculum problems, selection of subject matter in various fields, principles of program construction, and similar problems.

AdmS 466. Supervision of Instruction (3)
Analysis of the principles underlying the organization and supervision of instruction; application to specific teaching situations. K-12.

AdmS 473. Personnel Administration (3)
Overview of the personnel function in educational institutions. Trends in staff planning, recruitment, selection, assignment, and orientation, as well as tenure, grievances and related matters.

AdmS 474. Seminar in School Building (3)
Design, construction and modernization of educational facilities in terms of student, curricular, community and financial requirements.

AdmS 475. Educational Resources Management (3)
Systems designed to support educational decision-making. Analysis of conceptual designs for planning-programming-budgeting and evaluation systems (PPBS).

AdmS 476. School Finance (3)
Concepts of school finance including intergovernmental fiscal relations, state grants-in-aid, taxation, municipal borrowing, and long-term capital outlay programs.

AdmS 477. Seminar in School-Community Relations (3)
Analysis and development of the communication and public relations skills needed by educators in dealing with the public.

AdmS 478. Collective Bargaining in the Schools (3)
Contract negotiations, grievance, mediation, and arbitration for both professional and classified employees in education.

AdmS 479. School Law (3)
Effect of school law on administration of public school systems; analysis and synthesis of judicial interpretations of the constitutions, statutes, rules, regulations, and common law relating to educational issues.

AdmS 480. Administration of Student Service in Higher Education (3)
Administration of student services in higher education including welfare, control, activities, and teaching functions. Organization and operation; administrator's role in development and implementation of appropriate policies.

AdmS 481. Policy and Politics in Public Education (3)
Analysis of the forces, factors, agencies, formal governmental systems and informal sub-systems that influence educational policy in local districts and state and national governments.

AdmS 491-2. (I&C 491) Advanced Seminars in Education: with subtitle (1-3)
Intensive study and discussion of a specialized area. Title will vary. May be repeated for credit as title varies.

AdmS 493. (HD 493, I&C 493) Internship (3-9)
Opportunity for advanced students to obtain practical experience. Conference hours for students and staff members devoted to discussion of work and problems encountered in the schools. Prerequisite: consent of the program director.

AdmS 494. (HD 494, I&C 494) Field Work (3-6)
Identification of significant problems in an educational environment, review of the literature, and development of research plans. Three credits are the maximum permissable in a semester.

AdmS 495. (HD 495, I&C 495) Independent Study & Research (1-6)
Individual or small group study in the field of specialization. Approved and supervised by the major adviser. May be repeated for credit.

AdmS 496. (HD 496, I&C 496) Seminar in Research (3)
For doctoral students. Research design and application to various kinds of educational problems; data collection and analysis. Criticism and evaluation of student proposals. May be repeated for a maximum of nine credits.

Department of Human Development

Professors. Paul VanR. Miller, Ph.D., *chairman*; Andrew J. Edmiston, Ph.D.; Joseph P. Kender, Ed.D.; John A. Mierzwa, Ed.D.; Herbert Rubenstein, Ph.D.
Associate professors. Raymond Bell, Ed.D.; Warren R. Heyden-

berk, Ed.D.; J. Gary Lutz, Ed.D.; Artis J. Palmo, Ed.D.; William B. Stafford, Ed.D.
Assistant professor. John L. Manni, Ed.D.
Instructors. Elizabeth H. Conard, M.Ed.; Thomas J. Laffey, M.S.S.
Adjunct assistant professors. Louis Pica, Jr., M.Ed.; John C. Turoczi, Ed.D.

For Advanced Undergraduates and Graduate Students

HD 320. (Psych 320) Psycholinguistics (3)
Study of the experimental and observational literature on psychological processes involved in the production, comprehension and use of language by adults.

HD 324. (Psych 324) Lifespan Cognitive Development (3)
Changes in perception learning, memory and problem solving from infancy to old age.

HD 330. Study of the Individual (3-6)
Examinations of individual growth and development, especially the patterns found in different subcultures. Prerequisite: consent of the program director.

HD 341. The Teacher in Social Restoration (3-6)
Functions of the teacher and the school in prevention and remediation of antisocial behavior. Field work in remedial teaching and experience in social restoration institutions. For social restoration interns only.

HD 343. The Disadvantaged Student (3)
Philosophical analyses of disadvantagement and relevant educational theories. Applications and evaluations of special methods and techniques.

HD 351. Statistical Methods in Research (3)
Methods of describing and condensing sample data and drawing inferences about population characteristics. No background in statistics presumed. Emphasis on concepts.

HD 388. (Math 388) Computer Applications (3)
Writing and testing computer programs; use and adaptation of packaged programs; applications in behavioral research, administration, and instruction. Prerequisite: HD 407 or HD 408, or consent of the program director.

For Graduate Students

HD 400. Psychological Foundations of Education (3)
Psychological study of student development and the classroom environment.

HD 401. Learning Theories (3)
In-depth study of major classical and contemporary learning theories. Emphasis on application of theory to instruction and other educational procedures. Review of experimental research relevant to theories.

HD 402. Behavior Modification (3)
Theory and application of behavior modification methods in classroom and clinical settings. Methods derived from operant, classical, and cognitive models. Topics include behavior analysis, charting behaviors, outcome research, and ethical and philosophical issues. Prerequisite: HD 400 or its equivalent.

HD 403. (AdmS 403, I&C 403) Research (3)
Basic principles of research; techniques of gathering and analyzing data; design of studies in education. Emphasis on critical reviews of research reports representing various methodologies. Research report required.

HD 404. (I&C 404) Evaluation in Education (3)
Construction and evaluation of the teacher-made test. Selection of published tests and interpretation of individual and group results. Use and misuse of tests in assessing achievement.

HD 405. (I&C 405) Assessment of Exceptional Individuals (3)
Psychological and educational assessment procedures used with exceptional individuals. Understanding and applying information from psychological testing and utilizing formal education assessment and interviews.

HD 406. Standardized Tests and Measurements (3)
Principles of psychological measurements utilizing assessment techniques with focus upon standard group and individual tests. Administration and interpretation of tests. Prerequisite: HD 404 (I&C 404)

HD 407. Methods of Statistical Inference and Research Design (3)
Introduction to packaged programs for computer analysis. Analysis of variance and covariance in experimental designs. Multiple correlation and regression. Prerequisite: HD 351 or consent of the program director.

HD 408. Statistics I (3)
Data reduction, characteristics of frequency distributions, bivariate correlation and regression. Hypothesis testing, interval estimation, errors of inference, statistical power. Normal, t, F, and chi-square sampling distributions.

HD 409. Statistics II (3)
One-way and factorial analysis of variance and covariance. Multiple correlation and regression, partial and part correlation. Use of packaged programs for computer analysis. Prerequisite: HD 408 or consent of the program director.

HD 410. Statistics III (3)
Analysis of variance and covariance in higher-order experimental designs including factorial, incomplete factorial, nested, and repeated measures. Linear models approach. Prerequisite: consent of the program director.

HD 411. Multivariate Analysis (3)
Multinormal sampling distribution. Multivariate tests of significance, interval estimation, analysis of variance and covariance. Discriminant analysis, canonical correlation, introduction to factor analysis. Prerequisite: HD 410 or consent of the program director.

HD 412. Psychometric Theory (3)
Theory of measurement applied to various kinds of tests and scales. Item analysis; pretesting, scaling and equating; errors of measurement; reliability and validity; prediction. Prerequisite: HD 351 or 408 or consent of the program director.

HD 413. (I&C 413). Intern Teaching (3-6)
Intensive practice in the application of principles of teaching. Supervision is provided by the cooperating school and by the university. Prerequisite: consent of the program director.

HD 414 (I&C 414). Intern Teaching Seminar (3)
Critical analysis and discussion of classroom instructional practices. Discussion and illustration based on experiences of participants as they engage in intern teaching. Prerequisite: consent of the program director.

HD 420. Linguistics in Education (3)
The nature of language, phonetic applications and the relationships of linguistics to instruction in the language arts.

HD 422 (I&C 422). Language Development of Children (3)
The nature of language and its relation to the development of communication skills. Critical analysis of related research. Implications for the elementary school.

HD 424. Developmental Reading (3)
Introductory course spanning the elementary and secondary levels. Reading methods, materials, the disadvantaged and gifted reader, procedures for individualizing reading instruction. Field experience required.

HD 426. Diagnosis and Adjustment of Reading Difficulties (3)
Psychology of reading related to learning difficulties; measurement and diagnosis of reading difficulties; development of informal tests; materials for corrective and/or remedial instruction. Prerequisite: HD 424 or consent of the program director.

HD 427 (I&C 427). Children's Literature in Reading Instruction (3)
Role of literature in the instructional program of the elementary schools. Use of trade books for individual instruction in reading.

HD 428. Reading in the Content Areas (3)
Focuses on expository reading development in content areas such as language arts, mathematics, science and social studies. Practical teaching strategies in critical areas, such as comprehension and study skills. Review of research and methods for improving the reading development of students in grades 4 through 12.

HD 430. Advanced Topics in Reading (3)
Theory and research in historical background of reading instruction; cognitive, affective, and linguistic aspects of reading; implications for the disadvantaged and gifted reader. Field experience required. Prerequisite: HD 424 or consent of the program director.

HD 432. Reading Specialists Clinic (3-12)

HD 434. Seminar in Reading Research (3)
An advanced course dealing with critical appraisal and discussion of classical and current studies in reading.

HD 436. Practicum in Supervision of Reading Programs (3-6)
For candidates for supervisor's certificate in reading. Organization of the instructional program and duties involved in the supervisory processes in reading programs. Participation in supervisory activities.

HD 442 (I&C 442). Criteria- and Performance-Based Evaluation (3)
Measurement and evaluation theory and techniques with particular reference to criterion-based performance evaluation in vocational and career education.

HD 451. Philosophy and Principles of Guidance (3)
Theoretical foundations, principles and ethics of guidance processes, functions, services and organization of an educational guidance program.

HD 453. Consultation Procedures (3)
Observational methodology utilized in consultation; rationale, theory and methods of consultation; individual, group and parent consulting. Study of research on the consultation process.

HD 455. Career Development (3)
Process of selecting and pursuing educational and vocational goals; emphasis upon decision-making. Evaluating and using occupational, educational and related information.

HD 457. Counseling in the Community (3)
Community agencies are examined through readings, lectures and student presentations. Field investigation of a community counseling agency. Professional ethics, legal issues, accountability and organizational structure of agencies.

HD 459. Elementary School Guidance (3)
Roles of counselors, teachers, parents, and other specialists and their influence upon the development of the child. Practical concerns emphasized. Prerequisites: HD 451 and consent of the program director.

HD 461. Secondary School Guidance (3)
Establishment of a secondary guidance program within the school. Practical approaches to involve students, teachers, administrators, and parents in the guidance activities of the school.

HD 463. Counseling (3)
Theories and techniques of counseling. Students will practice counseling skills. Prerequisites: admission to a counseling program and HD 451 or 457.

HD 465. Introduction to Group Processes (3)
Introduction to the process of group counseling and group guidance. Selection of group members; group rules; group procedures with children, adolescents and adults; ethical consideration of groups. Study of research on group processes.

HD 467. Biofeedback in Counseling (3)
Theory and practice of biofeedback techniques; experience in using biofeedback instruments. Special attention paid to relaxation procedures and anxiety reduction. Prerequisite: HD 463.

HD 469. Group Counseling and Group Processes (3)
Group processes as related to counseling and guidance through class participation and demonstration. Prerequisite: HD 463 previously or concurrently.

HD 473. Personality and Adjustment (3)
Theories of personality and adjustment with emphasis on the adjustment processes in an educational setting. Prerequisite: consent of the program director.

HD 475. Theories of Psychological Counseling (3)
Analysis and synthesis of concepts drawn from counseling theorists. Research and current trends in counseling concerning educational, social and vocational problems. Prerequisite: admission to program in counseling.

HD 477. Current Issues in Counseling (3)
Examination of an area of counseling that is of topical interest to students and faculty. Permission of program director required. May be repeated for credit.

HD 481. Assessment in School Psychology (3-6)
Practice in the administration of individual tests and preparation of school psychological reports. Prerequisite: admission to program in school psychology.

HD 483. Diagnostic and Remedial Procedures in School Psychology (3)
Components that comprise a psychoeducational evaluation. Childhood disorders will be examined in relation to etiology, diagnostic criteria and appropriate intervention strategies. Integration of data from case histories, interviews and tests in making differential diagnoses. Prerequisite: HD 481.

HD 485. Seminar in School Psychology (3)
Role of the school psychologist, emphasis upon consultation. Legal aspects of school psychology. Prerequisite: admission to the school psychology program.

HD 487. Counseling and School Psychology Clinic (3-12)

HD 491-2. Advanced Seminars in Human Development: with subtitle (1-3)
Intensive study and discussion of a specialized area. Title will vary. May be repeated for credit as title varies.

HD 493 (AdmS 493, I&C 493). Internship (3-9)
Opportunity for advanced students to obtain practical experience. Conference hours for students and staff members devoted to discussion of work and problems encountered in the schools. Prerequisite: consent of the program director.

HD 494 (AdmS 494, I&C 494). Field Work (3-6)
Identification of significant problems in an educational environment, review of the literature, and development of appropriate research plans. Three credits is the maximum in one semester.

HD 495 (AdmS 495, I&C 495). Independent Study & Research (1-6)
Individual or small group study in the field of specialization. Approved and supervised by the major adviser. May be repeated.

HD 496 (AdmS 496, I&C 496). Seminar in Research (3)
For doctoral students. Research design and application to various kinds of educational problems; data collection and analysis. Criticism and evaluation of student proposals. May be repeated for a maximum of nine credits.

Department of Instruction and Curriculum

Professors. Alfred J. Castaldi, Ed.D.; Norman H. Sam, Ed.D.; John A. Stoops, Ed.D., distinguished professor of educational philosophy.
Associate professors. Robert L. Leight, Ed.D., *chairman*; Margaret C. Grandovic, Ed.D.; Alice D. Rinehart, Ed.D.; Elvin G. Warfel, Ed.D.
Assistant professors. Wesley C. Brown, Ph.D.; Spencer J. Salend, Ed.D.
Adjunct professor. Henry W. Ray, Ed.D.
Adjunct assistant professors. Kathleen A. Dalgaard, Ph.D.; Ruth B. Parr, M.A.

For Advanced Undergraduates and Graduate Students

I&C 301. Origins of Western Schools (3-6)
Study and travel seminar for experienced teachers. Nature and methods of Hellenistic and medieval schools; relevant traditions in language, art and philosophy; influences on American institutions. Summer session. Prerequisite: consent of the director.

I&C 312. Classroom Practice (1-3)
Experience in elementary and secondary classrooms as related to theories of child and adolescent development, classroom didactics, and philosophies of education. Problem-centered discussions, and observations. Prerequisite: consent of the program director.

I&C 313. Intern Teaching (3-6)
Intensive practice in the application of the principles of teaching. Supervision is provided by the cooperating school and by the university. Prerequisite: consent of the program director.

I&C 314. Intern Seminar (3)
Critical analysis and discussion of classroom instructional practices. Discussion and illustration based on experiences of participants as they engage in teaching experiences. Prerequisite: consent of the program director.

I&C 317. Instructional Media (3)
Principles underlying the use of graphics, and sound projection in teaching. Utilization of commercial, student, and teacher-made materials. Applications of new instructional media.

I&C 331. Emotional and Behavioral Disorders (2)
Study of types of disorders and pathology, etiology, various treatment plans. Approaches to working with clinical services and with parents.

I&C 332. Teaching the Emotionally and Socially Maladjusted (2)
Methods of gaining insight into and modification of behavior; appropriate curriculum, methods, materials, and available resources. Field observations.

I&C 333. Mental Retardation (2)
Etiology, degrees and clinical types of mental retardation; special needs of and vocational possibilities for the retarded; interdisciplinary approach.

I&C 334. Teaching the Mentally Retarded (2)
Current educational practices, curriculum, methods, and materials for promoting maximal social competency; available resources; legal and ethical rights of the retarded. Field observations.

I&C 335. Motor Development of Handicapped Children (2)
Methods of promoting sequential motor skills in handicapped children.

I&C 336. Teaching the Physically Handicapped (2)
Types of physical handicaps with attendant needs; appropriate curriculum, methods, materials and available resources; vocational possibilities. Field observations.

I&C 337. Arts for the Handicapped (3)
Study of the various artistic media (arts, crafts, music, puppetry, dramatics) which are helpful in promoting development of handicapped individuals.

I&C 338. Language and Social Development of Handicapped Children (2)
Methods of promoting sequential language and social skills in handicapped children.

I&C 340. Special Topics in Vocational and Career Education: subtitle (1-3)
Selected topics in vocational or career education of professional interest to faculty and students. Title will vary. May be repeated for credit as title varies.

I&C 341. Career Education for the Handicapped (3)
Promoting attitudes, work habits, and skills which enhance employability of the handicapped; appraisal of methods for matching individuals to jobs; job market for the handicapped; various curricular and administrative designs.

I&C 343. Occupations and Manpower (3)
Nature of work in America. Structure of the workforce. Work values and attitudes. Sources of occupational information. Methods of surveying manpower needs. Manpower programs. Labor organizations. Relationships between educational systems and the work world.

I&C 391-2. Workshops (1-3)
Cooperative study of current educational problems. Provides elementary, secondary, and special education teachers an opportunity to work at their own teaching levels and in their own fields. Limited to six credits during a summer session but the student may register for more than one workshop provided there is no duplication in subject matter.

I&C 394. Special Topics in Instruction and Curriculum: with subtitle (3)
Examination of a topic of research or professional interest in curriculum or instruction. Title will vary (e.g., Youth in Society, Child Development, Introduction to Foundations of Education). May be repeated for credit.

For Graduate Students

I&C 401. Sociological Foundations of Education (3)
The American school as a social institution, its cultural heritage, its purposes and processes in relation to social change and educational leadership; it's role in socialization and its responsibilities for relevance to social issues and to subcultural needs.

I&C 403 (AdmS 403, HD 403). Research (3)
Basic principles of research; techniques of gathering and analyzing data; design of studies in education. Emphasis on critical reviews of research reports representing various methodologies. Research report required.

I&C 404 (HD 404). Evaluation in Education (3)
Construction and evaluation of the teacher-made test. Selection of published tests and interpretation of individual and group results. Use and misuse of tests in assessing achievement.

I&C 405 (HD 405). Assessment of Exceptional Individuals (3)
Psychological and educational assessment procedures used with exceptional individuals. Understanding and applying information from psychological testing and utilizing formal education assessment and interviews.

I&C 406. Historical Foundations of Education (3)
Development of primary, secondary, and higher education; aims, curricula, methods, and systems of education in America from colonial time to present, in relation to social conditions.

I&C 407. Philosophical Foundations of Education (3)
Comparative philosophical analysis of educational aims, practices, and institutions. Major philosophical theorists whose work has influenced educational thought from ancient times to present.

I&C 408. Comparative Education (3)
Survey of educational practices abroad from nursery to graduate education. Systems of articulation, social foundations, legal foundations, and structure in government. Nature and purposes of the schools with reference to cultural patterns. Focus upon major problems and trends.

I&C 409. Values and Educational Purpose (3)
Modes of philosophical analysis used in justification of educational purposes. Presence of metaphysical, epistemological, and metaethical premises in educational opinion. Manifestations of values in contemporary school curricula and educational decisions. Professional ethics.

I&C 410. Structure and Syntax of the Academic Disciplines (3)
Professors from other disciplines analyze patterns which organize and identify the academic disciplines; the nature and significance of conceptual structures which guide inquiry or research; implications for planning of curricula and preparations of teaching materials.

I&C 411. Classroom Didactics (3-6)
Initial preparation of interns for classroom teaching. Secondary interns are trained in teaching methods in subject fields and the reading problems of secondary students. Elementary interns study teaching methods in the elementary school. Open to teaching interns only.

I&C 412. Participation in Teaching (3)
Study, directed observation of, and initial practice in the various phases of teaching in a campus laboratory-demonstration school or in area elementary and secondary schools. Prerequisite: consent of the program director.

I&C 413 (HD 413). Intern Teaching (3-6)
Intensive practice in the application of principles of teaching. Supervision is provided by the cooperating school and by the university. Prerequisite: consent of the program director.

I&C 414 (HD 414). Intern Teaching Seminar (3)
Critical analysis and discussion of classroom instructional practices. Discussion and illustration based on experience of participants as they engage in intern teaching. Prerequisite: consent of the program director.

I&C 416. Diagnostic and Prescriptive Teaching (3)
The role of the classroom teacher as an educational diagnostician. Emphasis on the nature and methods of informal educational diagnosis and specifics of prescriptive teaching in classrooms.

I&C 421. Child Development (3)
A study of physical, intellectual, emotional and social aspects of child development as they relate to the elementary schools.

I&C 422 (HD 422). Language Development of Children (3)
The nature of language and its relation to the development of communication skills. Critical analysis of related research. Implications for the elementary school.

I&C 423. Social Studies in Elementary Education (3)

I&C 424. Science in Elementary Education (3)

I&C 425. Fine Arts in Elementary Education (3)

I&C 426. Mathematics in Elementary Education (3)

I&C 427 (HD 427). Children's Literature in Reading Instruction (3)
Role of literature in the instructional program of the elementary schools. Uses of trade books for individual instruction in reading.

I&C 431. Education of Exceptional Children (3)
Curriculum, methods of instruction, and materials for individuals who differ markedly from the normal intellectually, physically, emotionally, or socially; the nature and causes of these differences; available resources. Field trips; direct work with exceptional children encouraged.

I&C 433. Learning Disabilities (3)
Types of specific learning disabilities and their effects on development and learning; physiological basis of learning and learning theory; various theoretical approaches, diagnostic and remedial procedures; practicum.

I&C 434. Learning Disabilities Practicum (3)
A ninety-hour practicum in the assessment and remediation of learning disabilities.

I&C 436. Developmental Learning Clinic (3)
Students with training in learning disabilities cooperate with school psychologists, reading specialists, and counselors in the assessment and formulation of prescriptive programs for children with special learning problems. Prerequisite: consent of the program director. May be repeated for credit.

I&C 441. Youth in Society (3)
Social development, characteristics, and problems of adolescents and young adults. Impact of relationships with siblings, peers, adults, subcultures, in the context of changing institutions and values.

I&C 442 (HD 442). Criteria- & Performance-Based Evaluation (3)
Measurement and evaluation theory and techniques with particular reference to criterion-based performance evaluation in vocational and career education.

I&C 450 (AdmS 450). Foundations of Curriculum Construction (3)
Principles of organization of programs of studies for elementary and secondary schools; origin and background of the curriculum; methods of organization; curriculum planning and development; pertinent applications. K-12.

I&C 452 (AdmS 452). The Elementary School Curriculum (3)
Problems of curriculum development in the first six grades; subject matter placement, program making for difficult types of schools, regular vs. special subjects, articulation.

I&C 454 (AdmS 454). The Secondary School Curriculum (3)
Methods of study of curriculum problems, selection of subject matter in various fields, principles of program construction, and similar problems.

I&C 491 (AdmS 491). Advanced Seminar in Education: with subtitle (3)
Intensive study and discussion of a specialized area. Title will vary. May be repeated for credit as title varies.

I&C 492. Advanced Seminar in Instruction and Curriculum: with subtitle (1-3)
Examination of an advanced topic in instruction or curriculum. Title will vary (e.g., Environmental Education, Teaching in Higher Education). May be repeated for credit as title varies.

I&C 493 (AdmS 493, HD 493). Internship (3-9)
Opportunity for advanced students to obtain practical experience. Conference hours for students and staff members devoted to discussion of work and problems encountered in the schools. Prerequisite: consent of the program director.

I&C 494 (AdmS 494, HD 494). Field Work (3-6)
Identification of significant problems in an educational environment, review of the literature, and development of appropriate research plans. Three credits is the maximum permissible in one semester.

I&C 495 (AdmS 495, HD 495). Independent Study & Research (1-6)
Individual or small group study in the field of specialization. Approved and supervised by the major adviser. May be repeated for credit.

I&C 496 (AdmS 496, HD 496). Seminar in Research (3)
For doctoral students. Research design and application to various kinds of educational problems; data collection and analysis. Criticism and evaluation of student proposals. May be repeated for a maximum of nine credits.

Electrical Engineering

Professors. Alfred K. Susskind, S.M., *chairman*; John J. Karakash, D. Eng., distinguished professor and dean of the College of Engineering and Physical Sciences; Walter E. Dahlke, Ph.D.; Nikolai Eberhardt, Ph.D.; Arthur I. Larky, Ph.D.; Daniel Leenov, Ph.D.; Kenneth K. Tzeng, Ph.D.; John G. Simmons, D.Sc., Ph.D., Sherman Fairchild professor of solid-state studies
Associate professors. Bruce D. Fritchman, Ph.D.; Frank H. Hielscher, Ph.D.; Carl S. Holzinger, Ph.D.; John G. Ondria, Ph.D.; Peggy A. Ota, Ph.D.
Assistant professor. Douglas R. Frey, Ph.D.
Instructor. Donald L. Talhelm, M.S.
Lecturers. Robert A. Donia, M.S.; John K. Redmon, M.S.; John F. Sipics, B.S.

Degree Programs

The department of electrical engineering offers two undergraduate degree programs, one leading to the bachelor of science in electrical engineering, the other to the bachelor of science in computer engineering.

The two programs are nearly identical until the middle of the junior year, and students can freely move from one to the other. The electrical engineering curriculum prepares graduates for entry into such areas as electronic devices, communication, information and computing systems, control systems, electronic instrumentation, and electrical power systems.

The computer engineering curriculum contains the basic elements of both hardware and software. Because of the pervasiveness of computers throughout modern technology, graduates find career opportunities not only in the computer industry, but also in a broad range of industrial as well as governmental activities.

Both undergraduate programs also can serve as stepping stones into such related areas as bioengineering, computer science, system engineering, or management science.

Courses in the department required for the degree in electrical engineering contain the fundamentals of computing techniques, linear circuits and systems, electronic circuits, signal theory, physical electronics, electromagnetic theory, and energy conversion. Some of these courses include laboratory work; two upper-level laboratory courses also are required. To facilitate increased emphasis on experimental work, the undergraduate laboratories have recently been renovated and reorganized.

Requirements for the degree in computer engineering include courses in computing techniques, linear circuits and systems, logic design, electronic circuits, signal theory, computer structure, systems programming, discrete mathematics, and numerical analysis. Laboratory sessions are part of some of these courses; two upper-level laboratory courses also are required.

A basic assumption underlying the curricula is that the variety of activities in which modern engineers are engaged will continue to remain large, and so provision for mobility of the individual is made by concentrating on broad fundamentals and not on the details of current engineering practice. As a consequence, subjects in physics and mathematics form a substantial block of courses in both curricula, because no matter which direction the individual will follow, such a foundation is essential.

Within electrical engineering, the physical sciences provide the foundation for studies of devices such as transistors, microwave components, and energy converters. Mathematics provides the basis for the analytical study of device models and the tools for the analysis, design and exploitation of systems such as computers, communication networks, and computer software.

About a quarter of the two curricula consists of approved electives, chosen with the consent of an adviser; the others require no formal approval. Together, these two groupings provide opportunity for tailoring the program according to individual interests and goals. Some students use the electives for acquiring additional background in preparation for graduate study. Others select senior-year courses in preparation for entry into industry after graduation.

Students are free to select from courses offered by other departments, and are encouraged to do so whenever it serves their individual needs. In this manner, they can prepare themselves for activities which straddle departmental boundaries, or for entry into professional schools such as medicine or management. To maximize the benefits that such flexibility can offer, thorough planning in consultation with an adviser is recommended.

In common with all engineering curricula, both degree programs require a total of at least eight courses in the humanities or the social sciences. Some students utilize this sequence to complete a minor program in one of the other colleges, such as a program in government, economics, or foreign languages. Advisers assist individuals in making appropriate arrangements.

Recommended Sequences of Courses

freshman year (see page 43)

sophomore year, first semester (17 credits)

EE 11	Principles of Computing Techniques (4)
Math 23	Analytic Geometry and Calculus III (4)
Phys 21, 22	Introductory Physics II and Lab (5)
Eco 1	Economics (4)

sophomore year, second semester (16-17 credits)

EE 20	Introduction to Circuit Theory (4)
Math 205	Linear Methods (3)
	General Studies Requirement (3)
	approved electives* (6-7)

*Note: These electives are to include Mech 103, Principles of Mechanics, for students seeking the electrical engineering degree; or EE 141, Switching Theory and Logic Design, for students seeking the computer engineering degree.

junior year, first semester (14-17 credit hours)

EE 104	Linear Systems and Signals (4)	
EE 105	Electronic Circuits (4)	
Math 231	Probability and Statistics (3)	*or*
Math 309	Theory of Probability (3)	
	General Studies requirement (3)	
	elective (0-3)**	

**Please refer to description of normal engineering program, page 43.

Bachelor of Science in Electrical Engineering

junior year, second semester (17 credit hours)

EE 103	Physical Electronics (3)
EE 106	Electromechanics and Machines (3)
EE 236	Electromagnetic Fields I (3)
EE 142	Junior Lab (2)
	approved electives (6)†

†Note: At least one subject must be in physics, chemistry or biology. Quantum mechanics is the best choice for those planning a program in electronics.

summer

EE 100	Industrial Employment

senior year, first semester (15-18 credits)

EE 111	Proseminar (1)
EE 151	Senior Lab I (2)
EE 237	Electromagnetic Fields II (3)
	approved electives* (6)
	elective (0-3)**
	General Studies requirement (3)

senior year, second semester (18 credits)
approved electives* (12)
elective (3)
General Studies requirement (3)

*Note: Approved electives are subjects predominantly in the areas of science and technology. They are not restricted to offerings in the department of electrical engineering. Students must choose at least one elective in mathematics and at least one elective in either materials, thermodynamics, fluid mechanics, or physical chemistry.
**Please refer to description of normal engineering program, page 43.

Bachelor of Science in Computer Engineering

junior year, second semester (17 credits)
EE 201 Computer Architecture (3)
EE 315 Principles of Computer Software (3)
EE 317 Analytical Methods for Information Sciences (3)
EE 142 Junior Lab (2)
approved elective† (3)
elective (3)

summer
EE 100 Industrial Employment

senior year, first semester (15-18 credit hours)
EE 111 Proseminar (1)
EE 151 Senior Lab I (2)
Math 230 Numerical Methods (3)
approved electives† (6)
elective (0-3)*
General Studies requirement (3)

*Please refer to description of normal engineering program, page 43.

senior year, second semester (18 credit hours)
approved electives† (12)
elective (3)
General Studies requirement (3)

†Approved electives are subjects in the area of science and technology. They are not restricted to offerings in the department of electrical engineering.

Course Descriptions

11. Principles of Computing Techniques (4) fall
Introduction to computational devices and their use. Topics include: computer organization, information representation, computational operations, data structures, machine assembly and high-level language programming techniques. Laboratory usage of microcomputers included. Prerequisite: Engr 1 or equivalent.

20. Introduction to Circuit Theory (4) spring, summer
Introduction to methods for analyzing lumped circuits. Topics include: circuit elements, formulation of differential equations, mesh and node analysis, network functions, natural frequencies, complete response calculations, pole-zero analysis, network theorems. Includes a weekly laboratory and/or problem-solving session. Prerequisite: Math 23.

100. Summer Work
Students are expected to spend at least eight weeks getting experience in some industrial organization, normally during the vacation following the junior year. A written report on the experience gained is required.

103. Physical Electronics (3) spring
Energy levels and band theory. Introduction to quantum statistics; electron emission and photoelectric effect; electron ballistics and applications. Conduction in metals and semiconductors; theory of p-n junctions and transistors; static and dynamic characteristics; equivalent circuits. Prerequisite: junior standing.

104. Linear Systems and Signals (4) fall
Transform theory, including Fourier and Laplace transforms. Application of transform techniques to the solution of linear system and circuit problems, including the use of Bode and pole-zero plots. Sampling theorem and its application to digital signal processing. Prerequisite: EE 20.

105. Electronic Circuits (4) fall
Introduction to methods for analyzing and designing circuits containing semiconductor devices such as diodes, bipolar transistors, and field-effect transistors for both small and large signal applications. Topics include device models, operating-point stabilization, basic amplifier configurations, power relationships, graphical and mathematical analysis techniques, introduction to multistage amplifiers and feedback. Includes a weekly laboratory. Prerequisite: EE 20.

106. Electromechanics and Machines (3) spring
Principles of electromagnetism and their application in electromechanical devices. Analysis and design of transformers, solenoidal actuators, multi-phase power systems, AC and DC rotating machinery, and machine control. Prerequisite: EE 20.

111. Electrical Engineering Proseminar (1) fall
A weekly seminar to acquaint students with current topics in electrical engineering. Students prepare and present oral and written reports which are judged on quality of presentation as well as technical content. Prerequisite: senior standing.

141. Switching Theory and Logic Design (3)
Boolean algebra and its application to networks with bivalued signals. Function simplification and design of combinational logic. Sequential machines and their realization in pulse and level circuits. Design of simple digital systems.

142. Junior Lab (2) spring
Experimental work related to EE 103, 104, 105, 106, 141 and 201, intended to strengthen proficiency in these fields. Two three-hour laboratory sessions per week. Prerequisite: junior standing.

151. Senior Laboratory I (2) fall
Laboratory projects in any phase of electrical and computer engineering, frequently in the areas of digital systems, communications, instrumentation, electronic circuits, and software. Projects are selected from topics suggested by the students, staff, or industrial concerns. Two three-hour sessions per week. Prerequisite: senior standing.

152. Senior Laboratory II (2) spring
Two choices open, each occupying two three-hour sessions per week.
1. Project laboratory. Similar to EE 151.
2. Microwave laboratory. Introduction to the standard techniques of measurement in the microwave range, such as measurement of impedance with the slotted line and the hybrid tee; two-port parameters; attenuation by substitution and heterodyning. Prerequisite: EE 346 previously or concurrently.

160. Introduction to Electrical Engineering (4) fall-spring
Survey subject for students not majoring in electrical engineering. Elementary network theory. Behavior of simple linear networks. Principles of semiconductor devices and their use in functional circuits, such as operational amplifiers and logic networks. Electromechanical energy conversion. Selected applications. Includes a weekly recitation session for review and discussion of assignments. Prerequisites: Math 23 and Phys 21.

162. Electrical Laboratory (1) fall-spring
Experiments on circuits, machines, and electronic devices. Prerequisite: EE 160 concurrently.

For Advanced Undergraduates and Graduate Students

201. Computer Architecture (3)
Digital building blocks, conventional computer structure and information flow. Mechanization of arithmetic, storage, and control functions. Input-output systems and controllers. Priority interrupt, direct memory access and other overlapping techniques. Architecture of small ("mini") computers; key features of large ("maxi") machines. Digital design simulation. Prerequisites: EE 11 or Math 105; EE 141 previously or concurrently. Larky

205. Pulse and Digital Circuits (3)
Concentration on large-signal, nonlinear, pulse-type circuitry employing devices such as diodes, transistors, silicon-controlled rectifiers, and operational amplifiers. Among topics covered are the internal workings and interface properties of major integrated digital circuit families (TTL, ECL and CMOS) and propagation of waveforms on transmission lines. Prerequisite: EE 105. Holzinger

212. Control Systems (3)
Introduction to feedback control. Dynamic analysis of linear feedback systems in the time and frequency domain, with emphasis on stability and steady-state accuracy. Major analytical tools: signal-flow graphs, root-locus method, Nyquist plot, Bode analysis. Cascade compensation techniques. Introduction to sampled data and state-variable concepts. Prerequisite: EE 104. Talhelm

233. Power System Analysis I (3)
Determination of transmission line constants; transmission line equations. Synchronous generator representation during steady state and transient conditions. Network reduction by matrix partitioning, network solutions by matrix transformations. Symmetrical components and system faults. Sequence impendances of transmission lines, transformer banks and synchronous generators. Prerequisite: EE 106. Sipics

234. Power System Analysis II (3)
Application of short-circuit impedance matrix to fault studies. Numerical methods for solution of the load flow problem. Economic despatch and unit commitment. Basic system stability consideration. Prerequisite: EE 233. Donia

236. Electromagnetic Fields I (3) spring
Electromagnetic Fields I and II provide theoretical foundations for understanding of electricity. EM-Fields I deals with mathematical foundations, such as vector analysis, and the theory of fields which are solutions to Laplace's equation (potential fields). Prerequisite: junior standing.

237. Electromagnetic Fields II (3) fall
Continuation of Electromagnetic Fields I. Time-varying fields which are solutions of Maxwell's equations. Main topics include: uniform plane waves in loss-free and lossy media; skin effect; Poynting's vector; guided waves in transmission lines and waveguides, including optical waveguides; reflection and refraction; microwave and optical resonators; antennae; Gaussian beams (laser beams). Prerequisite: EE 236 or equivalent.

244. Communication Networks (3)
Introductory theory of two-terminal and four-terminal network synthesis. Transmission lines as network elements. Analog and digital filter theory. Prerequisites: EE 104 and 105. Talhelm

300. Apprentice Teaching in Electrical Engineering (I-3)
See the introduction to this section.

307. Transistor Circuit Application (3)
Review of static and dynamic behavior of p-n junctions. Transistor physical electronics, volt-ampere characteristics, and circuit models. Dependence of circuit-model parameters on structure and operating conditions. Tuned amplifiers, feedback amplifiers, and oscillators. Prerequisite: EE 105. Ondria

308. Transistor Theory (3)
Theory of semiconductor devices. Small-signal and large-signal properties of p-n junction diodes including switching characteristics. Large-signal approximation for bipolar transistors, including Ebers-Moll and charge-control models. Deviations from low-level models at high injection levels. Other devices, including Schottky-barrier diodes, field-effect transistors, and p-n-p-n structures. Prerequisites: EE 103 and Phys 31. Leenov

311. Compiler Design (3)
Principles of artificial language description and design. Sentence parsing techniques, including operator-precedence, bounded-context and syntax-directed recognizer schemes. The semantic problem as it relates to interpreters and compilers. Dynamic storage allocation, table grammars, code optimization, compiler-writing languages. Prerequisite: consent of the chairman.

315. Principles of Computer Software (3)
Machine assembly and macro-language concepts. Study of assemblers, macro-processors, and loaders, and techniques for their construction. Introduction to operating systems as time permits. Prerequisite: EE 11 or consent of the chairman. Ota

317. (ICS 317, Math 317) Analytical Methods for Information Sciences (3)
Series of topics in discrete mathematics chosen for their applicability to computer science, coding theory, and information retrieval. Sets; binary relations; lattices; Boolean algebras and application to logic design; semigroups and relevance to automata; groups and application to coding; fields and relevance to circuits and codes; graphs and application to file searching. Prerequisite: senior standing or consent of the chairman. Tzeng

319. Digital System Design (3)
Design of combinational and sequential digital systems using standard logic elements, both SSI and MSI; characterization and application of flip-flops and other memory devices; input-output devices and the problems of interfacing to a computer; special-purpose digital systems. Prerequisite: EE 141. Larky

321. Current Topics in Magnetics (3)
Topics drawn from current areas of magnetic device theory and application, such as orthoferrite bubbles, magneto-optics, magnetic thin films, ferrites, and permanent magnets. Text material taken primarily from the current literature, with emphasis on computer applications. No specialized background assumed. Prerequisite: consent of the chairman. Holzinger

342. Communication Theory (3)
Theory and application of analog and digital modulation. Sampling theory with application to analog-to-digital and digital-to-analog conversion techniques. Time and frequency division multiplexing. Introduction to random processes including filtering and noise problems. Introduction to statistical communication theory with primary emphasis on optimum receiver principles. Prerequisites: EE 104 and Math 309 or 231. Fritchman

343. Digital Signal Processing (3)
Study of one- and two-dimensional orthogonal signal expansions and their discrete representations, including the Discrete Fourier Transform and Walsh-Hadamard Transforms. Development of fast algorithms to compute these, with applications to feature extraction and two-dimensional image processing. Introduction to the z-transform representation of numerical sequences with applications to input/output analysis of discrete systems and the design of digital filters. Analysis of the internal behavior of discrete systems using state variables for the study of stability, observability and controllability. Prerequisite: EE 104. Fritchman

346. Microwave Circuits and Techniques (3)
Impedance transformation along waveguides. Matching techniques. Resonant cavities as circuit elements. Scattering and transfer matrices. Periodic structures. Selected microwave devices. Basic techniques of microwave measurements. Prerequisite: EE 237. Eberhardt

350. Special Topics (3)
Selected topics in the field of electrical and computer engineering not included in other courses.

351. Microelectronics (3)
Technology of semiconductor devices and of integrated circuits, including crystal growth and doping, phase diagrams, diffusion, epitaxy, thermal oxidation and oxide masking, photolithography, thin film formation. Effects of these processes on the design of transistors and integrated circuits. Prerequisites: EE 103 and Phys 31 or consent of the chairman. Hielscher

355. Applied Integrated Circuits (3)
Emphasis on understanding of terminal characteristics of integrated circuits with excursions into internal structure only as necessary to assure proper utilization in system design. Classes of devices studied include operational amplifiers, digital-to-analog and analog-to-digital converters, linear multipliers, modulators, and phase-locked loops. Prerequisites: EE 104, 105. Holzinger

For Graduate Students

Graduate study leading to the master of science, master of engineering and doctor of philosophy degrees is available in the electrical engineering department. None of the advanced-degree programs has a fixed curriculum, and courses are selected by the individual in consultation with advisers.

Study leading to the master of science degree emphasizes the scientific aspects of electrical and computer engineering and requires the submission of a six-credit-hour thesis. Programs leading to the master of engineering include design-oriented courses and cover a range of areas. Completion of an engineering project is required.

Subject to approval by departmental advisers, graduate degree programs frequently include as part of the "major" courses offered by other departments. This is particularly appropriate in those areas where courses in physics and mathematics provide a foundation for advanced work.

Students in the doctor of philosophy program are required to take the qualifying examination within one year after obtaining the master's degree. This examination tests competency in general areas of electrical engineering. A second examination in the candidate's area of specialization is taken at some time up to the last year of the program. Competence in a foreign language is not a required part of the doctor of philosophy program in electrical engineering.

Members of the department are particularly interested in advanced work in the following areas: semiconductor devices; microwave components and circuits; electrooptics; instrumentation; computer languages; computer hardware and software systems; communications and decision theory; fault-tolerant computing; pattern recognition; algebraic coding theory; switching theory and logical design; solar radiation monitoring.

The facilities of the electrical engineering department are located primarily in Packard Laboratory. The department also shares the facilities of the Sherman Fairchild Laboratory and Lehigh's CDC 6400 computer and DEC system-20.

Facilities for experimental work in electronics and communication cover the spectrum through microwave frequencies and into optical wave lengths. Special research facilities, including a shielded room, are available for the study of devices, noise in semiconductor networks, and digital functions. The department has an HP-1000 computing system with a variety of peripherals, two PDP-8 minicomputers, numerous microcomputer systems, and a variety of ancillary building blocks.

Microelectronics facilities for the preparation and investigation of semiconductor devices, located in the Sherman Fairchild Laboratory, include equipment for diffusion, oxidation, photolithography, metallization, sputtering, and device assembly and testing. In addition, facilities of other departments including X-ray facilities, electron microscope, scanning electron microscope, electron microprobe, and Auger spectrometer, are available.

Courses for Graduate Students

403. Design of Operating Systems (3)
Principles of operating systems with emphasis on hardware and software requirements and design methodologies for multiprogramming systems. Global topics include the related areas of process management, resource management, and file systems. Prerequisite: EE 315 or equivalent. Ota

407. Linear and Nonlinear Optics (3)
Gaussian beams. Optical waveguides and resonators. Introduction to laser physics. Crystal optics with attention to nonlinear effects. Harmonic and subharmonic generation. Parametric amplifications. Brillouin and Raman scattering. Classical diffraction theory. Holography with applications. Eberhardt

409. Advanced Electromagnetic Theory (3)
Maxwell's equations in the scope of modern physics. Wave propagation in anisotropic and gyrotropic media. Introduction to nonlinear media. Atmospheric propagation and scattering. Selected topics from antenna theory. Eberhardt

411. Information Theory (3)
Introduction to information theory. Topics covered include: development of information measures for discrete and continuous spaces, study of discrete-stochastic information courses, derivation of noiseless coding theorems, investigation of discrete and continuous memoryless channels, development of noisy channel coding theorems. Fritchman

413. Active Networks (3)
Synthesis of active networks to prescribed frequency characteristics. Stability and realizability criteria. Parameter drift effects. Larky

425. Power System Analysis I (3-6)
Distribution-system concepts and components: transformers; protectives devices; voltage control; optimum loading; grounding. Protective relaying: operating principles and system calculations including fault calculations using symmetrical components. Surge phenomena: traveling-wave theory; grounding; surge-reduction design and arrester application; insulation coordination. Economics of power systems; analysis and evaluation of financial structure; rate of return; rate structures; depreciation. Redmon

426. Power System Analysis II (3-6)
Analysis of synchronous machines. Steady-state and transient modes of operation; per unit representation; d-q equations; balanced and unbalanced short-circuit stability; saturation. Stability criteria of power systems. State functions and state variables; system modelling; computer techniques; state-of-the-art analysis techniques; dynamic stability. Redmon

431. Topics in Switching Theory (3)
Emphasis on structural concepts motivated by recent advances in integrated circuit technology. Major topics include: logical completeness, error detection and location; decomposition techniques; synthesis with assumed network forms; fault masking in switching circuits. Prerequisite: EE 141 or equivalent.
Susskind

432. Finite State Machines (3)
Description of sequential behavior; Gendanken experiments; error control; information losslessness, iterative systems. Synthesis of sequential machines in canonic forms and as asynchronous circuits. Prerequisite: EE 141 or equivalent.
Susskind

435. Coding Theory (3)
General theory of error-correcting codes for error control in digital computer and communication systems. Topics include a review of modern algebra as required in the discussion of codes; the structure and properties of linear, cyclic, and convolutional codes for random or burst-error correction (or both); decoding algorithms and their circuit implementations. Prerequisite: EE 317 or Math 243 or equivalent. Tzeng

444. Microwave Devices (3)
Optical masers. Cavity and traveling wave masers. Devices using ferrimagnetic resonance: isolators, circulators, electronically controlled phase shifters. Parametric amplifiers. Amplifiers and oscillators using active semiconductor devices. Eberhardt

447. Nonlinear Phenomena (3)
Investigation of nonlinear effects in active and passive lumped and distributed circuits with emphasis on methods of analysis as well as physical understanding of jump phenomena, van der Pol's theory, stability criteria, phase locking. Transmission line and

optical waves in nonlinear media: shock waves, harmonic generation and optical parametric amplification. Eberhardt

448. (ME 448) Optimal Control and Design Theory (3)
Parameter optimization in design and optimal open-loop and feedback control via the extrema of unconstrained and constrained functions and functionals (calculus of variations). Matrix and state space formulation, Lagrange multipliers, Pontryagin maximum principle, Hamilton-Jacobi theory, matrix Ricatti equations, sensitivity analysis. Survey of observability and controllability, dynamic programming, and Kalman filter. Intended for engineers with a variety of backgrounds. Prerequisite: ME 340 or 343 or EE 212 or ChE 286. Bennet, Brown, Johnson

450. Special Topics (3)
Selected topics in electrical engineering not covered in other courses.

451. Physics of Semiconductor Devices (3)
Transport theory, lattice vibrations, electronic conduction, thermoelectric effects. Theory of recombination. Energy band structure. Applications to p-n junctions. Prerequisites: Phys 31 and EE 103 or equivalent. Dahlke

452. Theory of IMPATT and Gunn Diodes (3)
Hot electrons, secondary ionization, avalanche breakdown, electron transfer by intervalley scattering. Applications to microwave oscillators and amplifiers, such as avalanche and Gunn Diodes. Prerequisite: EE 451. Dahlke, Leenov

453. Theory of Field Effect and Tunneling Devices (3)
Properties of semiconductor surfaces: tunneling theory. Applications to tunnel diodes and field-effect transistors. Prerequisite: EE 451. Dahlke

454. Theory of Optoelectronic Devices (3)
Optical electronics. Theory of radiation, radiative absorption and emission in semiconductors. Applications to optical electronic devices: electroluminescence, light-emitting diodes, lasers. Detection and modulation of optical radiation, solar cells and photodetectors. Prerequisite: EE 451. Dahlke

456. Trapping in MOS Devices (3)
Equilibrium, quasi-equilibrium, and steady-state modes of operation of MOS devices. Statistics of occupation under steady-state conditions. Small-signal ac theory of discrete and distributed traps at the semiconductor-oxide interface and in the depletion region. Recombination, emission and nonsteady-state statistics of interfacial and bulk traps. Applications to the study of interface and bulk phenomena in MOS devices. Prerequisite: EE 451. Simmons

457. Modeling of Solid State Devices and Circuits (3)
Transient phenomena and modeling of bipolar and field-effect devices. Large-signal switching and modeling of digital devices and circuits including bipolar, MOS, CMOS, ECL and I^2L. Prerequisite: EE 451. Simmons

459. Fundamentals of Integrated Circuits (3)
Discussion of basic concepts which govern the design and performance of integrated circuits. Microelectronics technology, device physics and equivalent circuit models, effects of processing and parasitic elements on device performance. Circuit design considerations, with examples drawn from current linear and digital integrated circuits. Hielscher

460. Engineering Project (3-6)
Project work in an area of student and faculty interest. Selection and direction of the project may involve interaction with industry. Prerequisite: consent of the department chairman.

461. Theory of Electrical Noise (3)
Definitions: noise temperature, spectral density. Noise sources: quantum, thermal, shot, generation-recombination, flicker noise. Representation and optimization of noisy networks. Prerequisites: Phys 31 and EE 103 or equivalent. Dahlke

462. Noise in Microwave Devices and Networks (3)
Noise in electron tubes, bipolar and MOS transistors, mixers, parametric amplifiers, tunnel diodes, and masers. Prerequisite: EE 461. Dahlke

English

Professors. Frank S. Hook, Ph.D., *chairman*; Peter G. Beidler, Ph.D., Lucy G. Moses distinguished professor; James R. Frakes, Ph.D., Edmund W. Fairchild professor of American Studies; David M. Greene, Ph.D.; Albert E. Hartung, Ph.D., distinguished professor; John W. Hunt, Ph.D., dean of the College of Arts and Science; John F. Vickrey, Ph.D.
Associate professors. Rosemarie Arbur, Ph.D.; Addison C. Bross, Ph.D.; Jack A. DeBellis, Ph.D.; Edward J. Gallagher, Ph.D.; Robert R. Harson, Ph.D.; E. Anthony James, Ph.D.
Assistant professors. Jan S. Fergus, Ph.D.; Elizabeth N. Fifer, Ph.D.; Rosemary J. Mundhenk, Ph.D.; Tom Parks, Ph.D., director of The Learning Center; Barbara H. Traister, Ph.D.
Instructor. Michael Pressler, M.A.

The department of English offers majors in literature, journalism, and theater.

English and American Literature

Courses in English language and literature may be considered a general preparation for any decent kind of living. These courses require close attention to words, and at the same time encourage that loving respect for the true naming of things which is the source of all clear and honest thought.

In literature itself, which is words that we wish to hear again, and yet again, without change, we may find a happy companionship with minds that can help our own grow straight with grace. A head that is full of poetry is a good one to live with.

Undergraduate Major in English

The major in English is designed to give interested students: 1. experience in reading, analyzing, and formulating thoughts about what Matthew Arnold called "the best that has been thought and said"; 2. an understanding of how literary artists find the appropriate words to express their thoughts and feelings; and 3. a basic knowledge of the historical development of British and American literature.

Students who major in English often go on to careers in teaching, writing, law, or business, but the analytical and communication skills acquired in the study of literature and writing will be of use in almost any profession or human activity. Depending on their interests, abilities, and career plans, students who major in English are encouraged to consider double majors or minors in other fields. The major in English is flexible enough to allow this cross-discipline study with ease.

The student majoring in English has considerable freedom to choose from an extensive list of courses. To insure breadth of coverage, each major is required to take Engl 25 and 26, British Literature, and Engl 23, American Literature, first semester. These three courses are designed to acquaint the student with the important British and American writers, and with certain movements and trends in literature, before the twentieth century.

To insure depth of understanding of at least two basic early writers, each English major is required to take either Engl 329 or 330, Shakespeare and Elizabethan Drama, and either Engl 327, Chaucer, or Engl 331, Milton. In addition to these five courses, each English major elects five additional courses, in either English or American literature, at least two of which are in literature before 1900, and at least three of which are numbered above 300.

It should be emphasized that thirty is the minimum number of hours for the major; many English majors will elect to take more. Each English major has a departmental adviser to assist in selecting courses for the major program.

The department of English strongly recommends that any

student contemplating the possibility of advanced study of English or American literature or of becoming a teacher of English should work toward departmental honors.

In order to receive departmental honors the English major attains a 3.50 grade average in courses presented for the major and must complete 39 hours of course work in English. Fifteen of these hours (five courses) are those required for the regular English major: Engl 23, 25 and 26, Engl 329 or 330, and Engl 327 or 331. Twelve hours (four courses) should be chosen from among the department's advanced period courses (Engl 360, 362, 364, 367, 369, 371, 376, 377, 378, 379, 380, 385 and 386), at least two of which must be in literature before 1900; three hours (Engl 181) are in the form of a thesis of substantial length (normally 25 to 50 pages).

The department of English also recommends that students working for departmental honors elect Engl 148, Introduction to the English Language; that they develop a competency in at least one foreign language; and that they consider petitioning in their senior year to take one of the department's graduate seminars at the 400 level. Students who complete the courses required for departmental honors but who do not achieve the necessary grade-point average will receive the bachelor of arts degree with a major in English.

Minor in English

The department of English offers two minors, each requiring fifteen hours of course work beyond freshman English. To have entered on the transcript a minor in English, a student takes Engl 25 and 26, British Literature, and an additional nine hours in literature, at least six of them in British literature at the 300 level.

To have entered on the transcript a minor in American Literature, a student takes Engl 23 and 24, American Literature, and an additional nine hours in literature, at least six of them in American literature at the 300 level. The student's major adviser monitors the minor program. Either the student or the major adviser may consult with the department if there is a question about which courses are acceptable for credit toward a minor.

Graduate Work in English

The objective of the graduate program in English is not simply to impart knowledge, however wide or deep, but also to instruct the student in the methods of pursuing advanced study of literature and to provide training in the techniques of criticism and research, and in pedagogical approaches to literature.

A primary aim of the program is to furnish course work and individual instruction suitable for teachers of English at the secondary and college levels. Advanced degrees may be obtained in all areas of English and American literature. In 1977-78 about seventy candidates were enrolled in the graduate programs in English.

Students who wish to enter the graduate program in English should have an undergraduate major in English with at least fifteen semester hours of advanced courses in English literature. Students who did not major in English may be admitted, but will be expected to make up deficiencies in their undergraduate training in English in addition to satisfying other minimum requirements for the graduate degree sought.

Candidates for the master's degree in English who expect to continue for the doctor of philosophy degree are required to complete successfully twenty-seven semester hours of course work and to write a thesis representing the equivalent of three hours of course work. Master's degree candidates who do not wish to continue for the Ph.D. may, as an alternative, complete successfully twenty-seven hours of course work and pass an examination, preparation for which represents the equivalent of three hours of course work (see Engl 495). Details concerning the examination are available from the director of graduate studies.

Candidates for the master's degree whose needs and interests make it desirable may substitute up to six hours of collateral work in other departments. Master's candidates must take at least half of their required courses in 400-level seminars, but may select the balance of their curriculum from a variety of 300-level course offerings. Normally, at least six hours of course work for the master's degree must be in literature before 1660.

Candidates for the doctor's degree are accepted only after a consultation among the graduate professors concerning the candidate's qualifications. Each candidate is required to take at least one course from the following sequence: Engl 421, History of the English Language; Engl 423, Old English; and Engl 424, Beowulf.

The foreign language requirement for the doctor of philosophy (usually in Latin, French or German) may be satisfied in one of two ways: 1. the demonstration, through examination, of a reading knowledge of two foreign languages; or 2. the successful completion, concurrent with the graduate program, of a foreign language course, to be approved by the departmental director of graduate studies, at the 200, 300, or 400 level (or at a lower level in classical languages).

For the doctoral examination each candidate selects the following to be examined upon:

1. One of the following traditional periods: Old English and Medieval; Renaissance and Jacobean, 1500-1660; Restoration and Eighteenth century, 1660-1798; Romantic and Victorian, 1798-1900; American Literature, Colonial-1899; Modern Biritsh and American Literature, 1900-present.

2. A major figure, to be selected in consultation with the director of graduate studies and subject to the approval of the departmental graduate committee.

3. A genre, theme, matter, or customary grouping, to be selected in consultation with the director of graduate studies and subject to the approval of the departmental graduate committee.

In each of the three areas of the examination the candidate is expected to demonstrate the knowledge and expertise that would be necessary to teach a course in the subject. The three areas may not overlap except for, in rare instances, the third.

Freshman Courses

With the two exceptions noted below, all undergraduate students take six hours of freshman English courses: Engl 1 and one of the five options for the second semester, Engl 2, 4, 6, 8 or 10. The exceptions are:

1. Advanced placement and six semester hours of Lehigh credit for freshman English are given to students who earn a score of 5 on the CEEB Advanced Placement Test in English. These students need not take the regular freshman English courses (English 1, 2, 4, 6, 8, 10), but they are encouraged to elect Engl 11 and 12, seminars designed to give advanced freshmen practise in reading and writing at the college level. Students who receive a grade of 4 on the Advanced Placement Test in English or who have a score of 700 or higher on the SAT Verbal Aptitude Test will receive three hours of credit in freshman English; these students will complete the six-hour requirement by taking Engl 2, 4, 6, 8, 10, 11, 12 or 71. Students in this category should seek advice from the Department of English about which courses to roster. Students who have an SAT Verbal Aptitude Test score between 650 and 699 and who have received a grade of 3 on the CEEB Advanced Placement Test in English may apply to the Department of English for an anticipatory or special examination which, if completed successfully, will result in three hours of credit and exemption from Engl 1.

2. Undergraduate foreign students. Foreign students are students in the United States on non-immigrant visas.

Foreign students for whom English is not the native language are expected to have a level of proficiency in both oral and written English that will enable them to function adequately in their chosen curricula. All matriculating undergraduate foreign students whose native language is not English are required to take an English proficiency examination administered by the department. Those whose level of competence is judged to be adequate receive six hours of credit in English. Those whose level of competence is inadequate will be required to enroll in Engl 3, English as a Second Language, until they achieve the necessary level; at that time they will receive six hours of credit in English. The requirement is a competency requirement. No credit hours are given for the course; no grade is given in the course.

Foreign undergraduate students for whom English is the native language are treated as American students. Undergraduate students on immigrant visas and citizens of the United States, either by birth or by naturalization, for whom English is not the first language may petition to replace the regular freshman English requirement with the requirement for foreign students. Students who wish to be considered for this option should consult the department.

The Learning Center

As a part of the department of English, The Learning Center provides a variety of academic support services to Lehigh students. It is staffed by English professors and graduate teaching assistants, and it offers a full schedule of individualized tutorials, seminars, workshops, review sessions, and specific student-oriented materials in a language laboratory and computer-assisted program.

Courses in English

1. Composition and Literature (3)
The art of expository writing. Appropriate collateral reading.

2. Composition and Literature: Fiction, Drama, Poetry (3)
Continuation of Engl 1. Further practice in expository writing in conjunction with the study of drama, short fiction, and verse. Prerequisite: Engl 1.

3. English as a Second Language (0)
Oral and written English for non-native speakers. No grades are given. When students achieve the required level they receive six hours of credit in English.

4. Composition and Literature: The Novel (3) spring
Continuation of Engl 1. Further practice in expository writing in conjunction with the study of selected novels. Prerequisite: Engl 1.

6. Composition and Literature: Drama (3) spring
Continuation of Engl 1. Further practice in expository writing in conjunction with the study of literary and theatrical aspects of several classic and contemporary plays. Prerequisite: Engl 1.

8. Composition and Film Study (3)
Continuation of Engl 1. Further practice in expository writing in conjunction with the study of film.

10. Composition and Literature: Short Fiction (3) spring
Continuation of Engl 1. Further practice in expository writing in conjunction with the study of short stories and novellas. Prerequisite: Engl 1.

11. Literature Seminar for Freshmen (3) fall
Discussion of and writing about selected masterworks of literature. Open as an elective to any freshman exempt from the regular freshman English requirement.

12. Literature Seminar for Freshmen (3) spring
Discussion of and writing about selected masterworks of literature. Open as an elective to any freshman exempt from the regular freshman English requirement. Upon recommendation of the Engl 1 instructor, a freshman who has earned a grade of A may complete the freshman English requirement by taking this course instead of Engl 2, 4, 6, 8 or 10.

Basic Undergraduate Courses

The following courses are open to any student who has completed, or who has been exempted from, the required six hours of freshman English. Students may roster one of the following as a second English course to be taken concurrently with Engl 2, 4, 6, 8 or 10, if they have earned a grade of B or above in Engl 1 and if they obtain the consent of the instructor in the second course. The letters UP indicate that the course meets both preliminary and upperclass distribution requirements for students in the College of Arts and Science.

23. American Literature (3) UP fall
Significant American writing from the settlement through the middle of the 19th century. Prerequisite: six hours of freshman English.

24. American Literature (3) UP spring
American literature from the middle of the 19th century to the present. Prerequisite: six hours of freshman English.

25. British Literature (3) UP fall
British literature from *Beowulf* through the pre-Romantics. Prerequisite: six hours of freshman English.

26. British Literature (3) UP spring
British literature from Wordsworth to Auden. Prerequisite: six hours of freshman English.

27. Chaucer's Canterbury Tales (2) UP fall, 1978
Chaucer's *Canterbury Tales.* Meets with Engl 327, but has a reduced reading and written assignment load. Prerequisite: six hours of freshman English. Beidler

29. Shakespeare and Elizabethan Drama (3) UP fall
Selected plays, primarily by Shakespeare. Meets with Engl 329, but has a reduced reading and written assignment load. Prerequisite: six hours of freshman English. Hook, Traister

30. Shakespeare and Elizabethan Drama (3) UP spring
Continuation of Engl 29. Meets with Engl 330, but has a reduced reading and written assignment load. Prerequisite: six hours of freshman English. Hook, Traister

51. The Drama (3) UP fall
Selected plays; theories of drama; drama and the stage. Prerequisite: six hours of freshman English.

52. The Drama (3) UP spring
Continuation of Engl 51. Prerequisite: six hours of freshman English.

53. The Short Story (3) UP
English, American and continental short story. Class discussions, collateral reading, and reports. Prerequisite: six hours of freshman English.

55. The Novel (3) UP fall
Selected novels as works of literature. Prerequisite: six hours of freshman English.

56. The Novel (3) UP spring
Continuation of Engl 55. Prerequisite: six hours of freshman English.

57. Poetry (3) UP fall
Traditional and modern poetry read for pleasure and understanding. Prerequisite: six hours of freshman English.

59. World Literature (3) UP fall
Great works from the literature of epic poetry, drama, romance, and essay which illustrate the humanistic traditions of Western civilization. Prerequisite: six hours of freshman English.

63. Narrative Cinema (3)
Historical periods and aesthetic innovations of narrative fictional cinema of Europe and the United States. Prerequisite: six hours of freshman English. Pressler

71. Expository Writing Workshop (1-3) UP
Practice in and criticism of expository writing beyond the freshman level. May be repeated for credit as topic varies. Prerequisite: six hours of freshman English.

73. Creative Writing Workshop (1-3) UP
Practice in and classroom criticism of creative writing done by students taking the course. Title may vary: Short Story; Drama; Poetry; etc. May be repeated for credit. Prerequisite: six hours of freshman English.

75. Individual Authors (1-3) UP
Intensive study of the works of one or more literary artists. Title will vary: Emily Dickinson; Swift and Jefferson; Yeats, O'Casey, and Joyce; etc. May be repeated for credit as title varies. Prerequisite: six hours of freshman English.

77. Individual Works (1-3) UP
Intensive study of one or more literary works. Title will vary: *Moby-Dick;* Medieval Mystery Plays; *Morte Darthur, Idylls of the King,* and *The Once and Future King*; etc. May be repeated for credit as title varies. Prerequisite: six hours of freshman English.

79. Character Types in Literature (1-3) UP
Study of a character type in several works of literature by several authors. Title will vary: The Mad Scientist in Drama and Fiction; The Devil in Literature; The Lawyer in Modern Literature; etc. May be repeated for credit as title varies. Prerequisite: six hours of freshman English.

81. Themes in Literature (1-3) UP
Study of a recurring theme as it appears in several works of literature. Title will vary: Pastoralism; Utopias in Literature; The Oedipus Complex in Literature Before and After Freud; etc. May be repeated for credit as title varies. Prerequisite: six hours of freshman English.

83. Popular Literature (1-3) UP
A form of literature which is or has been of interest primarily to a "popular" audience. Title will vary: Folklore; Detective Fiction; The Western Novel; etc. May be repeated for credit as title varies. Prerequisite: six hours of freshman English.

85. Performing Literature (1-3) UP
Study of and practice in literature to be performed before an audience. Title will vary: Literature Aloud; Opera As Literature; etc. May be repeated for credit as title varies. Prerequisite: six hours of freshman English.

89. Science Fiction (3) UP
The genre with emphasis on its role as creator and reflector of attitudes toward scientific and technological advances. Prerequisite: six hours of freshman English. Gallagher, Arbur

91. Special Topics in English (1-3) UP
A characteristic topic or genre or approach in literature not covered in other courses. Prerequisite: six hours of freshman English.

Undergraduate Courses in English

The following courses are more advanced than the courses which appear in the preceding list, but they are by no means designed exclusively for specialized students. Each course is a self-contained unit and has no prerequisites beyond the two semesters of freshman English.

The purpose of most of the courses listed below is to acquaint students from all segments of the university with the best that has been written through the ages by the most effective literary artists. *These courses may be used to fulfill preliminary or upperclass distribution requirements for students in the College of Arts and Science.*

148. Introduction to the English Language (3) spring
Basic linguistic concepts together with a historical survey of the English language. Vickrey

150 (Phil 150). Media and Values (3) fall, 1979
How mutual interaction forms and reforms media and values. Humanistic criticism and philosophical analysis of the principal media (the human body, language, film, television, architecture, art) through which human values arise and take their place in the world. DeBellis, Haynes

181. Undergraduate Thesis (3)
Open to advanced undergraduates who wish to submit theses in English. Prerequisite: consent of the department chairman.

183. Readings in English and American Literature (3)
Open to advanced students who wish to pursue speical or independent courses of reading in literary study. Prerequisite: consent of the department chairman.

263. Aesthetics of Cinema (3)
Major theoretical and critical writing about the motion picture: methodology of textual film analysis. Prerequisite: Art 5 and Engl 63 previously or concurrently, or consent of the department chairman. Pressler

300. Apprentice Teaching (3)
Supervised participation in various aspects of the teaching of a course. Prerequisite: consent of the department chairman.

301. Topics in Literature (1-3)
A theme, topic, or genre in literature. Title will vary. Contemporary Drama; Autobiography as Literature; Literary Censorship; etc. May be repeated for credit as title varies.

303. Advanced Expository Writing (3)
Practice in writing: structure and style. Students select their own subject. Prerequisite: Engl 71 or consent of the chairman.

311. Literature of Women (3) fall, 1980
Literature by and about women, including both acclaimed and little-known works. Arbur

312. Jewish Literature (3) spring, 1980
Development of Jewish literature (including Yiddish literature in translation) from Russian and Eastern European beginnings to immigration and assimilation in America. Fifer

316. The Indian in American Literature (3) spring, 1981
The American Indian as portrayed in folklore, poetry, and fiction in America. Works written by both Indian and non-Indian writers.

319. The Black in American Literature (3) fall, 1979
Black characters and the literary treatment of the black experience in American fiction and drama from 1850 to the present. Comparative examination of both black and non-black authors, such as W. W. Brown, Stowe, Melville, Twain, Chesnutt, Hughes, Toomer, Faulkner, Wright, Baldwin, Ellison, Styron and Baraka. Frakes

327. Chaucer (3) fall, 1980
The chief works of Geoffrey Chaucer, with attention to his language and the backgrounds of his works. Beidler

328. Shakespeare Laboratory (0-1)
Selected plays as scripts for theatrical production. Scheduled concurrently with Engl 329 or 330. Students who desire to use this course as an alternative to papers and examinations in Engl 329 or 330 should roster 0 credit hours. Hook, Traister

329. Shakespeare and Elizabethan Drama (3) fall
Development of the English drama, including the important plays of Shakespeare. Hook, Traister

330. Shakespeare and Elizabethan Drama (3) spring
Continuation of Engl 329. Hook, Traister

331. Milton (3) fall, 1979
Life and works of John Milton in connection with the history of his times and the chief sources of his inspiration. Greene

360. Middle English Literature (3) spring
Major literary works of the Middle English period by authors other than Chaucer; some works in translation, some in the original. Emphasis on Langland, Gower, the Pearl Poet, and the metrical romances. Hartung

362. The Renaissance (3) spring, 1980
English nondramatic literature in the 16th century and the stimulus of the Italian Renaissance and northern humanism. Readings in and class discussions of the works of the chief writers — Petrarch, Erasmus, More, Wyatt, Surrey, Lyly, Sidney and Spenser. Greene

364. The Seventeenth Century (3) spring, 1981
English literature of the 17th century, from Donne to Dryden. Traister

367. The Eighteenth Century (3) fall, 1979
Great British writers of the 18th century, beginning with the Restoration. Particular attention paid to Dryden, Pope, Swift, Defoe, Fielding and Johnson and his circle. James

369. British Romantic Literature (3) fall, 1981
Poetry and prose of Wordsworth, Coleridge, Byron, Shelley and Keats within the contemporary political, religious and social context. Harson

371. British Victorian Literature (3) fall, 1980
Poetry and prose of Tennyson, Browning, Arnold, Swinburne,

Carlyle, Mill, Newman, and Ruskin within the contemporary political, religious and social context. Bross

376. Early American Literature (3) spring, 1980
American literature to the Romantic period. Gallagher

377. American Romanticism (3) fall, 1981
The chief American Romantics—Emerson, Thoreau, Whitman, Hawthorne, Melville and Dickinson. The European and American philosophical, historical and social background as well as the aesthetic study of romantic masterpieces. Arbur, DeBellis

378. American Realism (3) spring, 1981
Theory and practice of realistic fiction from the Civil War to the early 20th century: Twain, Howells, James, Norris, Crane, Chopin, Dreiser, and others. Frakes

379. Twentieth-Century American Literature (3) fall, 1980
American literature before World War II. Lectures and class discussion of major fiction and poetry. DeBellis, Mundhenk

380. Contemporary American Literature (3) spring, 1980
American literature since World War II. Lectures and class discussions of new writers and of recent works of established writers. DeBellis, Frakes

382. Themes in American Literature (3) spring, 1980
Intensive study of one topic in American literature. Readings from the colonial period to the present. Sample topics: The American Rediscovery of Europe; The Theme of Apocalypse; American Humor; The Edenic Motif; Personal Revolt and Social Protest. May be repeated for credit as topic varies. Frakes

383. Modernism and Post-Modernism in Fiction (3) fall, 1980
The "anti-realistic" novel; time/space, point of view, narrative voice, structure as meaning. Kafka, Woolf, Beckett, Nabokov, Robbe-Grillet, Faulkner, Borges, Hawkes, Stein. Frakes

385. Twentieth-Century World Literature (3) fall, 1979
World English literature and continental literature before World War II. Lectures and class discussion of major fiction and poetry. Bross

386. Contemporary World Literature (3) spring, 1981
World English literature and continental literature since World War II. Lectures and class discussions of new writers and of recent works by established writers. Frakes

Graduate Courses in English

The following courses are seminars, ordinarily limited to no more than twelve graduate students, but undergraduate English majors who are planning to go on to graduate school in English and who have shown proficiency in the study of literature may petition to take one of these seminars in their senior year. The courses are offered at varying intervals.

421. History of the English Language (3)
The phonology, grammar and lexicon of English from the beginnings to the present. Vickrey

423. Old English (3)
Old English language and literature. Vickrey

424. Beowulf (3)
The Beowulf poem and some of the pertinent scholarship. Vickrey

427. Chaucer (3)
The life and works of Chaucer. Readings, reports and discussions. Hartung

428. Chaucer (3)
Continuation of Engl 427. Hartung

429. Middle English Metrical Romances (3)
Middle English non-Arthurian verse romances. Hartung

431. Arthurian Literature of the Middle Ages (3)
Arthurian literature from its Celtic beginnings to Malory's *Morte Darthur*. Hartung

433. Middle English Literature (1-3)
A topic, a genre, or a grouping of works or authors in the Middle English period. Sample offerings: The Medieval Humorous Tale; Medieval Drama. May be repeated for credit as title varies. Beidler

439. Sixteenth-Century British Literature (3)
A topic, a genre, or a grouping of works or authors in the 16th century. Sample offerings: 16th-Century Drama; Spenser. May be repeated for credit as title varies. Hook, Traister

441. Seventeenth-Century British Literature (3)
A topic, a genre, or a grouping of works or authors in the 17th century. Sample offerings: Jacobean and Caroline Drama; Metaphysical Poetry. May be repeated for credit as title varies. Hook, Traister

443. Eighteenth-Century British Literature (3)
A topic, a genre, or a grouping of works or authors in the 18th century. Sample offerings: Augustan Satire; The Rise of the Novel; Boswell, Johnson, and their circle. May be repeated for credit as title varies. James, Fergus

445. Nineteenth-Century British Literature (3)
A topic, a genre, or a grouping of works or authors in the Romantic or Victorian periods. Sample offerings: Tennyson and Browning; Wordsworth and Byron; The Victorian Novel. May be repeated for credit as title varies. Bross, Harson, Mundhenk

449. Twentieth-Century British Literature (3)
A topic, a genre, or a grouping of works or authors in 20th-century literature of the British Isles. Sample offerings: Conrad; Joyce. May be repeated for credit as title varies. Greene, Frakes

471. Early American Literature (3)
A topic, a genre, or a grouping of works or authors of colonial America or the early republic. Sample offerings: The Roots of the American Dream; Science and Religion in the Colonial Period. May be repeated for credit as title varies. Gallagher

473. American Romanticism (3)
A topic, a genre, or a grouping of works or authors in the American Romantic period. Sample offerings: The Nature of Evil in Hawthorne, Melville, and Poe; Hawthorne's and Melville's Narrators. May be repeated as title varies. Arbur, DeBellis

475. American Realism (3)
A topic, a genre, or a grouping of works or authors in American literature from the Civil War to World War I. Sample offerings: James; American Literary Naturalism. May be repeated for credit as title varies. Frakes

477. Modern American Literature (3)
A topic, a genre, or a grouping of works or authors in the literature written after World War I. Sample offerings: Hemingway and Faulkner; The Apocalyptic Vision; Southern Writers; Modern American Poetry. May be repeated for credit as title varies. DeBellis, Frakes

481. Literary Criticism (3)
Theory and practice of criticism. The nature and function of literature itself, the assumptions and methodologies of major 20th- century critical "schools," and similar topics, regarded as objects of knowledge and as models for students' own critical reading, writing, and teaching. May be repeated for credit as topic varies. Arbur

485. Teaching of College English (3)
History, theory, and practice of teaching the freshman composition course. Required of all new teaching assistants in the department of English. May be rostered by others only with consent of the department chairman. Mundhenk

489. Workshop for English Teachers (1-3)
Study of a body of information with particular emphasis, through reports and discussion, on how the information can best be taught to secondary and college students. Sample topics: Shakespeare for

Teachers; Teaching the American Literature Survey; Teaching the British Literature Survey; Teaching the Novel; Teaching poetry. May be repeated for credit as topic varies.

491. Speical Topics (1-3)
Selected topics in the field of English not covered in other courses. May be repeated for credit as topic varies. Prerequisite: consent of the director of graduate studies.

493. Graduate Seminar (3)
Intensive study of the works of one or more authors, or of a type of literature, or of the teaching of an author or a type of literature. May be repeated for credit as topic varies.

495. Independent Study (3)
Independent study in approved areas. To be rostered by candidates for the master of arts degree in English who desire to take an examination on selected figures rather than submit a thesis. Prerequisite: consent of the director of graduate studies.

Journalism

Professors. Joseph B. McFadden, M.A., *head*; Robert J. Sullivan, M.A.
Assistant professors. Sharon M. Friedman, M.A.; Walter W. Trimble, M.A.

Journalism is concerned with the exercise of social responsibility in human affairs. The profession of journalism deals with the truthful communication of facts and their explanation. It is the purpose of the program in journalism to bring its majors: 1. to the point where they can gather significant information, organize it quickly into effective form, and communicate it clearly, accurately, and with a disciplined objectivity; and 2. to an understanding of the legitimate role of the press in society.

The first of these objectives is obtained by extensive, professionally oriented practice in the writing, reporting, and editing of news. The skill thus acquired is firmly rooted in rigorous training in vocabulary, in precision of expression, and in sophistication in style. It is concerned with clear writing and careful reporting, the kind that depicts the meaning of events. It develops from a purposeful curiosity and a capacity to be imaginatively interested in human activity.

The second objective is obtained: 1. by study of the rights and responsibilities of the press under the U.S. Constitution, with emphasis upon the freedom of the press as conditioned by the liberties of the individual and the needs of society; 2. by examination of the journalistic tradition in the United States in relation to the political, economic, scientific, and social progress of the population; and 3. by independent study, culminating in an undergraduate thesis, of the press and society.

The basic program in journalism provides opportunity for concentration in at least one of the following areas: American Studies, business management, economics, government, history, international relations, languages, literature, philosophy, religion studies, science, social relations, and urban studies.

A second option for those wishing to major in journalism is to concentrate in science writing. Those selecting this major will learn to write about pure and applied scientific research, technology and engineering, medicine, and the environment. A minor in science writing also is available for those who wish to major in another field such as science or engineering but become skilled in science communication techniques.

For persons interested in environmental writing, a bachelor of science degree in Environmental Sciences and Resource Management (ESRM) with a concentration in environmental science writing is offered through the ESRM interdisciplinary program in cooperation with the division of journalism. Students are required to take a core sequence of sixty-six credit hours in preliminary science courses and eighteen credits in the science writing program, plus electives. For details refer to the ESRM program description on page 140.

All science and environmental writing students also may enroll in the Science Writing Field Research Program, which offers a unique opportunity for practical experience in the field of science writing and research.

Although the great majority of graduates in journalism enter some phase of written communication as a career—daily newspaper, wire services, magazine, public or industrial relations, advertising, technical writing—others have used their background in journalism as a basis for the study and practice of law, service in government, teaching, business management, and graduate study in a variety of disciplines.

Those concentrating in science writing can expect to pursue careers in science journalism with either general or specialized publications; in public information or public relations for scientific societies, government agencies, universities, industries, hospitals, etc.; in technical writing; or in related areas in which science communication skills are highly desired such as management, teaching, and administration. The program also prepares students for graduate study in science writing, general journalism and a number of other disciplines.

Basic Journalism Major

required preliminary courses

Journ 1, 2	Brown and White (2)
Journ 11	News Writing (4)

required major courses

Journ 3-8	Brown and White (2-6)
Journ 17	Magazine Article Writing (3)
Journ 113	Editing (3)
Journ 114	Reporting of Public Affairs (4)
Journ 115	Interpretive Writing (3)
Journ 120	Journalism Proseminar (3)
Journ 122	Law of the Press (3)

Note: *Brown and White* must be rostered each semester while the student is a journalism major, and a minimum of four such semesters is required. With the approval of the journalism faculty, current professional newspaper or other media experience may be substituted semester for semester.

Dual Majors and Recommended Electives

Journalism majors are encouraged to declare dual majors in journalism and another field, such as one of those discussed under concentrations above. In-depth knowledge of a specialty area is considered an asset to a journalism career. Those not desiring to declare a dual major should consider either declaring a minor in one of these fields or concentrating their elective courses in one or two of these areas. Dual majors, minors and concentration areas should be chosen in consultation with the major adviser.

Journalism/Science Writing Major

required major courses

Journ 1-8	Brown and White (1-8)	
Journ 11	News Writing (4)	*or*
Journ 123	Basic Science Writing (3)	
Journ 113	Editing (3)	
Journ 114	Reporting of Public Affairs (4)	
Journ 122	Law of the Press II (3)	
Journ 124	Politics of Science (3)	
Journ 125	Environment, the Public and the Mass Media (3)	
Journ 126	Writing About the Environment (3)	
Journ 313	Speical Topics in Science Writing (3)	

Note: Those concentrating in science writing must roster *Brown and White* each semester after declaring the major. A minimum of four such semesters is required. Current professional newspaper or magazine experience may be substituted semester by semester.

required science courses. A minimum of twenty-four credits in the physical, biological, environmental or social sciences or engineering is required. These hours can be concentrated in any one area or distributed among all five areas, although an area concentration is recommended. Dual majors in journalism/science writing and a

science are encouraged. Science courses should be chosen in consultation with the major adviser.

Science Writing Field Research Program

Available to science or environmental writing students at the junior or senior level, this program provides practical experience in scientific research and science writing for students who work on and write about research projects directed by university scientists and engineers.

Another segment of the program allows students to attend major scientific meetings as fully accredited science reporters. Students observe professional science writers in action and write about the scientific sessions and press conferences held at the meetings.

Journalism Minor

Students who wish to declare a minor program in journalism must be majors in another discipline and take the following:

Journ 1-3	Brown and White (3)
Journ 11	News Writing (4)
Journ 113	Editing (3)
Journ 115	Interpretive Writing (3)
Journ 122	Law of the Press II (3)

Sixteen credits are required.

Science Writing Minor

Students desiring to minor in journalism/science writing should be majors in another discipline, preferably a science. The following courses are required:

Journ 1-2	Brown and White (2)
Journ 11	News Writing (4) *or*
Journ 123	Basic Science Writing (3)
Journ 124	Politics of Science (3)
Journ 125	Environment, the Public and the Mass Media (3)
Journ 126	Writing About the Environment (3)
Journ 312	Advanced Science Writing (3) *or*
Journ 313	Special Topics in Science Writing (3)

Seventeen credits are required.

Journalism Courses

Media Internships
With the approval of the journalism faculty, qualified students may acquire professional experience with area newspapers and magazines or in institutional and agency advertising and public relations.

1-10. Brown and White (1-2)
Enrollment constitutes membership on the staff of the semiweekly undergraduate paper. Students enrolling for the first semester register for Journ 1; for their second semester, Journ 2, etc. Prerequisite: consent of the division head.

11. News Writing (4) every semester
Definition, determinants, and components of news; news story structure and style; sources; interviewing; practice in gathering and writing news. Sullivan, Trimble, Friedman

17. Magazine Article Writing (3) fall
Writing and marketing nonfiction magazine articles.
McFadden

21. Creative Writing (3)
The study and writing of fiction, short stories, especially with a view to developing each student's particular talent. Prerequisite: consent of division head and Engl 2, 10, 14 or 16. McFadden

22. Creative Writing (3)
Continuation of Journ 21. Prerequisite: consent of the division head and Engl 2, 10, 14 or 16. McFadden

113. Editing (3) fall
Study of and practice in newspaper desk work; headline writing, makeup, and typography; selecting, editing and rewriting news and feature copy; use of reference works and newspaper libraries. Prerequisite: Journ 11. Sullivan, Trimble

114. Reporting of Public Affairs (4) spring
Reporting and writing news of government on the local, county, state and federal levels; civil and criminal courts; labor, environment, housing and community planning news. Prerequisite: Journ 11 and Govt 77. Friedman, Trimble

115. Interpretive Writing (3) spring
Editorial interpretation of current events; practice in interpretive writing, including editorials. Prerequisite: Journ 11. Sullivan

118. History of American Journalism (3)
English background of the American newspaper; development of press from colonial days to the present; influence of newspapers on American life; contributions of outstanding journalists. Friedman, Trimble

120. Journalism Proseminar (3) fall
Survey of the press in its relation to public affairs. Extensive research and reports. Prerequisite: consent of the division head. McFadden

121. Law of the Press (3)
Constitutional development of freedom of the press; rights and responsibilities of the press. McFadden

122. Law of the Press II (3) spring
Law of and defenses in libel; privacy; contempt; copyright; obscenity. McFadden

123. Basic Science Writing (3) fall
Writing news and feature articles on scientific and technological subjects for the mass and specialized media. Prerequisite: six hours of science or consent of the division head. Friedman

124. (HPT 124) Politics of Science (3) spring
Organization of the U.S. scientific community and how it interacts with government, the mass media and the public.
Friedman

125. Environment, the Public and the Mass Media (3) fall
Public perceptions of environmental problems and of roles played by business, government, the mass media and environmental groups. Analysis of techniques of persuasion, with student investigations of regional environmental problems. Friedman

126. Writing About the Environment (3) spring
Practice in techniques of environmental public relations, including press releases, public service announcements, newsletters, reports and pamphlets. Environmental persuasion campaigns for actual clients. Prerequisite: Journ 125 and either Journ 11 or Journ 123, or consent of the division head. Friedman

131. Science Writing Practicum (1-3)
On-site experience as accredited science reporter at major scientific meetings, or writing and research in university laboratories as part of Science Writing Field Research Program. May be repeated for a maximum of eight credits. Prerequisites: Journ 11 or Journ 123 or Journ 311, junior standing, and consent of the division head. Friedman

161. Internship (1-3)
Professionally supervised work on commercial newspapers, magazines, radio and television stations, or with public relations and advertising organizations. Some internships involve science writing. May be repeated for a maximum of six credits. Prerequisite: consent of the division head.

211. Problems in Advanced Reportage (3)
Intensive practice in the reporting of complex events. Prerequisite: Journ 114. Trimble

212. Problems in Advanced Reportage (3)
Continuation of Journ 211. Prerequisite: Journ 114. Trimble

311. Science Writing (3) fall
Study of and practice in writing about science and technology for general print, electronic media and specialized science publications. Includes news and feature articles, report writing and analysis of factors that influence science communication to the public. Emphasis on writing and organizational skills and translation of scientific material into lay language. Should be taken by upperclass and graduate students instead of Journ 123. Prerequisite: six hours of science or consent of the division head. Friedman

313. Special Topics in Science Writing (3)
Interpretive feature writing on controversial or complex scientific and technological topics. Emphasis on in-depth investigations, interviewing, and balanced reporting. Prerequisite: Journ 11, or Journ 123, or Journ 311, or consent of division head. Friedman

Speech and Theater

Professors. Thoburn V. Barker, M.A.; Frank S. Hook, Ph.D.
Associate professor. Jeffrey Milet, M.F.A., *head.*
Assistant professor. James Hill, M.F.A.
Instructors. Ann Roth, B.F.A.; Jessica Woods, B.F.A.

The bachelor of arts in theater is given after a progam of study in the traditional theatrical skills. The major in theater requires a minimum of thirty hours of course credit. In order to enjoy broader opportunities for the application of their skills, students are encouraged to consider interdisciplinary and double majors. Minors in speech and theater are offered.

Students prepare for graduate work or professional apprenticeship programs. The program also prepares students to apply their talents and training to a wide variety of related or associated fields. Working together, students, faculty and visiting professionals, prepare productions in the Wilbur Drama Workshop.

Theater Major

Core (required of all majors)

Theater 15	Introduction to Technical Theater (3)
Theater 41	Acting I (3)
Theater 71	Introduction to Theater History (3)
Theater 144	Basic Directing (3)

Option I. Acting/Directing

required courses

Theater 16 or 18	Introduction to Lighting or Scene Design (3)
Theater 42	Acting II (3)
Theater 141	Acting III (3)
Theater 143	Movement for the Stage (3)
Theater 245	Advanced Directing (3)
Speech 138	Voice and Articulation (3)

Option II, Design/Technical Theater

required courses

Theater 16	Introduction to Lighting (3)
Theater 18	Introduction to Scene Design (3)
Theater 96	Costume Design (3)
Theater 116	Advanced Technical Theater (3)
Theater 117	Advanced Lighting (3)
Theater 118	Advanced Scene Design (3)

Substitutions can be made only with consent of division head. Majors are expected to augment their major program with suggested electives in other departments.

Theater Minors

Acting/Directing Minor

Theater 15	Introduction to Technical Theater (3)
Theater 41	Acting I (3)
Theater 71	Introduction to Theater History (3)
Theater 144	Basic Directing (3)

plus Theater 42 or 245

Technical Theater Minor

Theater 15	Introduction to Technical Theater (3)
Theater 16	Introduction to Lighting (3)
Theater 18	Introduction to Scene Design (3)

and two of the following:

Theater 116	Advanced Technical Theater (3)
Theater 117	Advanced Lighting (3)
Theater 118	Advanced Scene Design (3)
Theater 119	Special Technical Studies (3)

Substitutions can be made only with consent of division head.

Speech Minor

Speech 30	Fundamentals of Speech (3)
Speech 31	Business and Professional Speaking (3)
Speech 130	Public Speaking (3)
Speech 138	Voice and Articulation (3)

and one of the following for a total of fifteen credits:

Speech 33-35	Impromptu Speaking (1)
Speech 37	Oral Interpretation (3)

Undergraduate Courses

Theater 1. Introduction to Theater (3) P
Theater concepts for the intelligent playgoer: significance of theatrical space, visual and aural effects; the actor at work; role of director and designer; what goes on backstage. Students will observe rehearsals and performance of plays produced by the division of theater. Course may not be included in either the major or minor in theater.

Theater 11-13. Basic Production (1)
Practical experience in all forms of theater art. Students enrolling for their first semester register for Theater 11; for their second semester, Theater 12, etc.

Theater 14. Theater Sound (1)
Techniques, materials, and methods of designing sound for theatrical production. Prerequisite: consent of the division head.

Theater 15. Introduction to Technical Theater (3) UP
Concepts and ideas of technical theater. Relationship of technical theater to theater in general. Stagecraft, scenery construction, and drafting for theater. Materials and methods of technology.

Theater 16. Introduction to Lighting (3) UP
Stage lighting: tools, concepts and aesthetics. The lighting designer as creative theatrical aritst. Prerequisite: Theater 15 or consent of the division head.

Theater 18. Introduction to Scene Design (3) UP
The scene designer as creative artist: tools and concepts. History of theatrical design as related to development of theater. Play ideas expressed through scenic design. Prerequisite: Theater 15 or consent of the division head.

Speech 30. Fundamentals of Speech (3)
A foundation course designed to develop knowledge of the basic principles of speech and ability to communicate.

Speech 31. Business and Professional Speaking (3)
Development of speech for business and professional problems; technique of expository speaking; use of visual graphics; persuasive speaking applied to the emotional or analytical approach in selling; methods of interviewing; techniques of conference. Prerequisite: consent of the division head.

Speech 33-35. Impromptu Speaking (1)
The organization and presentation of short expository speeches and of speeches for special occasions. Content drawn from contemporary events. Students enrolling for their first semester register for Speech 33; for their second semester Speech 34, etc. Prerequisite: consent of the division head.

Speech 37. Oral Interpretation (3)
The analysis and oral presentation of various types of literature. Consideration of sound values, rhythm and imagery. Prerequisite: consent of the division head.

Theater 41. Acting I (3) P
Techniques of the 20th century actor. Vocal production, stage movement, improvisational acting, characterization. Some laboratory projects in special areas, some scene study.

Theater 42. Acting II (3) UP
Basic knowledge of the physical stage. Understanding entrances, exits, scene text; actions of, objectives of, and relationships among roles. Prerequisite: Theater 41 or consent of the division head.

Theater 51. Special Projects (3) UP
Exploration of specialized areas of theater practice. Prerequisite: consent of the division head.

Theater 61. Theater Production I (3)
Theatrical production related to theater as a whole. Techniques and concepts applied to actual production. Prerequisite: consent of the division head.

Theater 62. Theater Production II (3)
Continuation of Theater 61. May be taken three times for credit with consent of the division head. Prerequisite: Theater 61 and/or consent of the division head.

Theater 71. Introduction to Theater History (3) UP
Survey of the history of the theater in the western world from the Greeks to the 20th century.

Theater 81. Theater Management (3) UP
Techniques, concepts and business practices related to management in the theater.

Theater 85. Production Seminar (3) UP
Study and practice in literature to be performed before an audience.

Theater 96. Costume Design (3) UP
History and development of theatrical costuming. Wardrobe as it relates to art and culture. Supervised practice.

Theater 116. Advanced Technical Theater (3)
Stagecraft, scenery construction, rigging, and materials for theater. Prerequisite: Theater 15 or consent of the division head.

Theater 117. Advanced Lighting (3)
Continuation of Theater 16: aesthetics and artistic concepts, lighting design for various theatrical forms, and practical experience. Prerequisites: Theater 25, 16, and 18, or consent of the division head.

Theater 118. Advanced Scene Design (3)
Continuation of Theater 18: advanced design problems, research, and methods of presenting design ideas. Prerequisites: Theater 15, 16 and 18, or consent of the division head.

Theater 119. Special Technical Studies (3)
Independent study of topics not covered by other courses. Prerequisite: consent of the division head.

Speech 130. Public Speaking (3)
Continuation of Speech 30 with emphasis on structure and outlining of various types of speeches. Prerequisite: Speech 30.

Speech 138. Voice and Articulation (3)
Speech improvement in terms of voice production and articulation. Use of the phonetic alphabet for developing clearer speech. Recommended for those who seek to correct acquired speech patterns and for students of theater.

Theater 141. Acting III (3)
Further study of the actor's techniques. Prerequisites: Theater 41 and 42, or consent of the division head.

Theater 143. Movement for the Stage (3)
Exercises for body tone, flexibility, control and agility. Practice in developing center and body areas in order to develop characterizations physically. Prerequisite: Theater 41 or consent of the division head.

Theater 144. Basic Directing (3)
Survey of theatrical direction. Study of the emergence of the director. Prerequisite: theater 41 or consent of the division head.

Theater 172. Special Studies in Theater History (3)
Selected periods of theater history. Students work independently on a period of their own choice. Prerequisite: Theater 71.

Theater 173. Special Studies in Theater History (3)
Continuation of Theater 172. Prerequisite: Theater 172.

Theater 243. Acting IV (3)
Continuation of Acting III. May be taken three times for credit with the consent of the division head. Prerequisite: Theater 141 or consent of the division head.

Theater 245. Advanced Directing (3)
Extension of Theater 144. Student analysis and formulation of a directorial approach, culminating in the production of a full-length play. Prerequisite: Theater 144 or consent of the division head.

Theater 271. Playwriting (3)
Study of the resources and techniques of the dramatist. Critical analysis of the playwright's creative process and practice in creating smaller dramatic forms. Prerequisite: Theater 41 and 144, or consent of the division head.

Theater 351. Advanced Special Projects (3)
Exploration of specialized areas of theater practice. Prerequisite: consent of the division head.

Fine Arts

The department of Art and Architecture is the current name for what was long known as the department of fine arts. See Art and Architecture for course descriptions.

Environmental Sciences and Resource Management

Edward B. Evenson, Ph.D., *director*, environmental sciences and resource management and assistant professor of geological sciences.

Society's increasing demands for energy, water, mineral commodities, food, recreational and living space have altered and will continue to alter the global ecosystem. The need for personnel

trained to evaluate proposed alterations and to repair existing deleterious or critical situations can best be met by an interdisciplinary approach. Additionally, there is a pressing need to communicate about environmental problems at all levels of society, from the scientist to the layman. Writing about the environment can best be done by persons trained in both science and communication skills.

Environmental sciences and resource management is an interdepartmental major fostering basic preparation for advanced study or an immediate career in environmental management, conservation and environmental science writing. The backgrounds of fundamental mathematics and science required to understand the interactions of humans and their environment are established early in the major where the student is exposed to the core courses of mathematics, chemistry, physics, biology and geology.

Following this basic preparation, students select a concentration area within which more advanced training is undertaken. Concentrations in biology, chemistry, geology and environmental science writing have been established and concentrations in other fields can be designed to meet the needs and career desires of individual students.

Student research in specific problems involving laboratory, field, library or mass media research is an integral part of the program and is strongly encouraged.

Graduates of this major can expect to take part in planning, education, research and coordination of environmental programs for all levels of government and industry. Those concentrating in environmental science writing also can pursue careers in science journalism or in professions such as environmental law or environmental management, where communication skills are highly desired. Graduate study is advisable for students wishing to pursue a career in most aspects of environmental science and the program provides thorough preparation for advanced training in environmental science or concentration areas.

Bachelor of Science Degree

The program requires 120 credit hours. Credit is allocated as follows: 36 credits for college and university requirements, 66 credits in preliminary courses, and 18 credit hours in the area of concentration.

college and university requirements (36 credit hours)

Engl 1	Composition and Literature (3)
Engl 2, 10, 14 or 16	Composition and Literature (3)
	general electives (3)

Note: General elective courses are non-professional courses designed to give the student a broad understanding in traditional and contemporary fields of thought outside of natural science and mathematics. The courses are chosen by the student. The elective program includes a number of courses broadly distributed among the various areas of the humanities and the social sciences.

required preliminary courses (66 credit hours)

Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry and Calculus II (4)
Math 23	Analytic Geometry and Calculus III (4)
Phys 11	Introductory Physics I (4)
Phys 12	Introductory Physics Laboratory I (1)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
Chem 21	Introductory Chemical Principles (4)
Chem 22	Chemical Principles Laboratory (1)
Chem 23	Analytical Environmental Chemistry (3)
Chem 51	Organic Chemistry (3)
Chem 53	Organic Chemistry Laboratory (1)
Geol 1	Principles of Geology or Geol 101 (3)
Geol 2	Introductory Geology Laboratory (1)
Geol 12	Historical Geology and Stratigraphy (3)
Geol 33	Introductory Mineralogy and Petrology (3)
Geol 211	Environmental Geology (3)
Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Laboratory (1)
Biol 135	Microbiology (3)
Biol 306	Ecology (3)
Biol 303	Invertebrate Zoology (3) *or*
Biol 331	Nonvascular Plants (3) *or*
Biol 332	Vascular Plants (3) *or*
Biol 34	Comparative Anatomy (3)
Eco 311	Environmental Economics (3)
CE 371	Environmental Health Engineering (3) *or*
Biol 361	Sanitary Microbiology (3)

Concentrations

Eighteen credit hours are required. Students select and fulfill one of the following concentration areas:

geology

Geol 23	Structural Geology (3)
Geol 312	Geomorphology (3)
Geol 313	Sedimentology (3)
Geol 333	Crystallography (3)
Geol 341	Field Camp (6)

biology

Biol 28	Genetics (3)
Biol 303	Invertebrate Zoology (3) *or*
Biol 331	Non-vascular Plants (3) *or*
Biol 332	Vascular Plants (3) *or*
Biol 34	Comparative Anatomy (3)
Biol 309	Aquatic Biology (3)
Biol 322	Animal Physiology (3)
Biol 317	Evolution (3)
Chem 52	Organic Chemistry (3)

chemistry

Chem 52	Organic Chemistry (3)
Chem 54	Organic Chemistry Lab (2)
Chem 187	Physical Chemistry (3)
Chem 191	Physical Chemistry (3)
Chem 234	Analytical Chemistry Lab (1)
Chem 334	Chemical Oceanography (3)
Chem 332	Analytical Chemistry (3)

environmental science writing

Journ 123	Basic Science Writing (3)
Journ 124	Politics of Science (3)
Journ 125	Environment, the Public and the Mass Media (3)
Journ 126	Writing About the Environment (3)
Journ 313	Special Topics in Science Writing (3)
Journ 17	Magazine Article Writing (3) *or*
Journ 114	Reporting of Public Affairs (3) *or*
Journ 113	Editing (3) *or*
Journ 312	Advanced Science Writing (3)

Recommended Sequence of Courses

freshman year, first semester (15 credit hours)

Math 21	Analytic Geometry and Calculus I (4)
Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
Engl 1	Composition and Literature (3)
	general elective (3)

freshman year, second semester (14 credits)

Math 22	Analytic Geometry and Calculus II (4)
Geol 1, 2	Principles of Geology and Laboratory (4)
Engl 2, 10, 14, or 16	Composition and Literature (3)
	general elective (3)

sophomore year, first semester (16 credits)

Math 23	Analytical Geometry (4)
Phys 11, 12	Introductory Physics I and Laboratory (5)
Biol 1, 2	Principles of Biology and Laboratory (4)
Geol 211	Environmental Geology (3)

sophomore year, second semester (14 credit hours)

Phys 21, 22	Introductory Physics II and Laboratory (5)
Geol 12	Historical Geology and Stratigraphy (3)
	general elective (3)
	concentration course (3)

junior year, first semester (16 credit hours)

Chem 51, 53	Organic Chemistry and Laboratory (4)
Eco 311	Environmental Economics (3)

Geol 33	Introductory Mineralogy and Petrology
	concentration course (3)
	general elective (3)

junior year, second semester (15 credit hours)

Chem 23	Analytical Environmental Chemistry (3)
Biol 306	Ecology (3)
	concentration course (3)
	general electives (6)

summer

Geol 341	Field Camp (6). Geology concentration only.

senior year, first semester (15 credit hours)

Biol 331	Evolution of Nonvascular Plants (3) *or*
Biol 303	Invertebrate Zoology (3) *or*
Biol 332	Vascular Plants (3) *or*
Biol 34	Comparative Anatomy (3)
Biol 35	Microbiology (3)
	concentration course (3)
	general electives (6)

senior year, second semester (15 credit hours)

CE 371	Environmental Health Engineering (3) *or*
Biol 361	Sanitary Microbiology
	concentration courses (6)
	general electives (6)

Five-Year Programs

Other program combinations leading to two degrees can be found under Arts-Engineering sequences or may be developed by consulting Graduate School requirements and the chairman of the appropriate department.

Electrical Engineering and Engineering Physics

This curriculum is particularly well suited for students seeking thorough preparation in the field of physical electronics. The program adds to the basic electrical engineering curriculum a sequence of upper-level undergraduate physics courses.

The electrical engineering degree is conferred on the completion of the fourth year, and the engineering physics degree at the end of the fifth year. Both are bachelor of science degrees.

freshman year in engineering (see page 43)

sophomore year, first semester (17 credits)

EE 11	Principles of Computing Techniques (4)
Math 23	Analytical Geometry and Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
Eco 1	Economics (4)

sophomore year, second semester (16 credits)

EE 20	Introduction to Circuit Theory (4)
Math 205	Linear Methods (3)
Phys 31	Introduction to Quantum Mechanics (3)
	General Studies requirement (3)
	elective (3)

junior year, first semester (14-17 credit hours)

EE 104	Linear Systems and Signals (4)
EE 105	Electronic Circuits (4)
Math 231	Probability and Statistics (3) *or*
Math 309	Theory of Probability (3)
Phys 212	Electricity and Magnetism (3)** *or*
	elective (0-3)
	General Studies requirement (3)

junior year, second semester (17 credit hours)

EE 103	Physical Electronics (3)
EE 106	Electromechanics and Machines (3)
EE 236	Electromagnetic Fields I (3) *or*
Phys 212	Electricity and Magnetism I (3)
EE 142	Junior Lab (2)
	mathematics elective (3)
	elective (3)

summer

EE 100	Industrial Employment

senior year, first semester (15-18 credit hours)

EE 111	Proseminar (1)
EE 151	Senior Lab I (2)
EE 237	Electromagnetic Fields II (3) *or*
Phys 213	Electricity and Magnetism II (3)
Phys 215	Particles and Fields I (3)
EE	departmental electives (6)
	elective (0-3)*

*Please refer to description of normal program, page 43.
**Students may substitute EE 236 and 237 for Phys 212 and 213.

senior year, second semester (18 credit hours)

Phys 216	Particles and Fields II (3)
EE	departmental electives (9)
	General Studies requirement (3)
	elective (3)

fifth year, first semester (17 credit hours)

Phys 192	Advanced Lab (2)
Phys 340	Thermal Physics (3)
Phys 362	Atomic and Molecular Structure (3)
Math 322	Methods of Applied Analysis I (3)
	approved elective (3)
	elective (3)

fifth year, second semester (15 credit hours)

Phys 254	Optics Lab (2)
Phys 171	Proseminar (1)
	approved electives (6)
	electives (6)

Note: Approved electives are two courses selected from Phys 363, 364, 365, 366, 367, 368, 369.

Engineering—Master of Business Administration

This program is designed to meet the needs of competent students in any of the engineering curricula who want to add to their engineering studies training in business management at an advanced level.

The time involved is five years, but a summer session is necessary to attain both a bachelor's degree in engineering and a master's degree in business administration or management science. In addition to a course in economics, which is required of all engineering undergraduates, thirty hours of basic business courses are necessary to meet the background requirement for the master of business administration degree. If as much as eighteen hours of such courses can be rostered in the student's engineering curriculum, the remaining twelve hours can be obtained in one summer. Otherwise, attendance at an additional summer session is necessary. Candidates for each program take the Graduate Management Admission Test, and meet the standards for admission into the Graduate School.

For background courses required for the master of business administration, engineering students should see Section IV, Graduate Study in Business and Economics, and consult with Max D. Snider, associate dean of the latter college.

Arts-Master of Business Administration

This program is designed to meet the needs of students in the College of Arts and Science who want to add to their arts studies training in business management at an advanced level.

The time involved in the program is five years, but a certain amount of summer session work may be necessary for majors in the sciences to attain both the bachelor of arts and the master in business administration within that period. In addition to one course in economics, which can be counted as part of the social science distribution requirements, thirty hours of basic business courses are needed to meet the background requirements. Thirty hours of requirements for the master of business administration degree also are required. Candidates are required to take the Graduate Management Admission Test and to meet the standards for admission into the Graduate School.

For background courses for the master of business administration, students should see Section IV, Graduate Study in Business and Economics, and consult with Max D. Snider, associate dean of that college. Many background courses can be rostered in the student's arts curriculum.

Civil Engineering and Geological Sciences

This program is designed for students interested in geological engineering, and leads to two bachelor of science degrees, in civil engineering and in geological sciences, both awarded at the end of the fifth year. The total number of credits in the program is 179, including two summer camps which comprise nine credits.

The program provides alternatives for students who may decide not to complete the two-degree program. Students who make this decision prior to the beginning of the fourth year may qualify at the end of that year for the bachelor of science in civil engineering, as well as a minor in geological sciences. On the other hand, if a student decides after two years, to pursue only the bachelor of science in geological sciences, it is possible to complete the requirements in four years. If the decision to work toward this degree is made during the fourth year, at least one additional semester is required to qualify for either bachelor degree.

freshman engineering year (see page 43)

second year, first semester (16 credit hours)

Math 23	Analytical Geometry and Calculus III (4)
Mech 1	Statics (3)
CE 9	Civil Engineering Computations (1)
CE 11	Engineering Graphics (2)
Chem 31	Chemical Equilibria in Aqueous Systems (3)
Geol 101	Geology for Engineers (3)

second year, second semester (17 credit hours)

Phys 21, 22	Introductory Physics II and Laboratory (5)
Mech 11	Mechanics of Materials (3)
Met 92	Structure and Properties of Materials (3)
CE 40	Surveying Principles I (3)
Geol 12	Historical Geology and Stratigraphy (3)

summer

CE 41	Surveying Principles II (3)

third year, first semester (18 credit hours)

Math	elective (3)
CE 109	Numerical Techniques (2)
CE 121	Mechanics of Fluids (3)
CE 143	Soil Mechanics (3)
Geol 33	Introductory Mineralogy and Petrology (3)
Eco 1	Economics (4)

third year, second semester (18 credit hours)

Mech 104	Dynamics and Vibrations (3)
CE 170	Environmental Engineering Flow Systems (3)
CE 222	Hydraulic Engineering (3)
Geol 23	Structural Geology (3)
Geol 356	Ground Water (3)
elective	H-SS (3)

summer (3 credit hours)

CE 100	Summer Employment

fourth year, first semester (18 credit hours)

CE 159	Structural Analysis I (3)
Geol 301	Introduction to Geophysics (3)
Geol 313	Sedimentology (3)
Geol 333	Crystallography (3)
elective	(Engr. Science) (3)
elective	H-SS (3)

fourth year, second semester (19 credit hours)

Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Laboratory (1)
CE 160	Structural Design (3)
Geol 312	Geomorphology (3)
elective	geology (3)
elective	eng. science (3)
elective	H-SS (3)

summer (6 credit hours)

Geol 341	Field Geology (6)

fifth year, first semester (19 credit hours)

CE 200	Engineering Planning (3)
CE 203	Professional Development (3)
CE 207	Transportation Engineering I (3)
Geol 334	Petrology and Petrography (4)
electives	H-SS (6)

fifth year, second semester (15 credit hours)

elective	engineering design (3)
elective	geology (3)
electives	H-SS (9)

H-SS indicates subjects in the humanities and social sciences.

Foreign Careers

Gerald Garb, professor of economics and *director of the Foreign Careers program.*

Major in the College of Arts and Science

The interdepartmental major in foreign careers is designed to give students the grounding in language, history, economics, and related subjects needed for successful work with private industry or governmental agencies in their overseas activities.

Each student in the program schedules all courses in the common core and in one of the options. In addition, the student will, in consultation with the director, select courses in language, history, and other subjects which will provide an intensive knowledge of the culture of the area of interest. Students should study the language related to their areas of specialization or special interest.

The program also affords a broad base for graduate study in social sciences and business administration. Students interested in this aspect of the major sequence should consult the director early in the college career.

Common Core

required preliminary courses

Eco 1	Economics (4)
Govt 3	Comparative Politics (3)
Math 21	Analytic Geometry and Calculus I (4) or
Math 41	BMSS Calculus I (3)
Eco 45	Statistical Method (3)

Concentration in the Latin American Area

Eco 305	Economic Development of Latin America (3)
SR 367	Change and Conflict in Latin America (3)
Hist	six hours of Latin American History (6)

Concentration in the European Area

Eco 309	Comparative Economic Systems (3)
Eco 343	European Economic Integration (3) or

IR 101	Politics of European Integration (3)
Hist	six hours of European history (6)

Concentration in the Russian Area

Eco 309	Comparative Economic Systems (3)
Govt 61	The Soviet Political System
IR 133, 134	Diplomacy of Russia (6)
IR 334	The Soviet Union in World Affairs (3)

Foreign Trade Option

Acctg 51	Essentials of Accounting (3)	*or*
Acctg 108	Fundamentals of Accounting (3)	
Eco 105	Microeconomic Analysis (3)	
Eco 119	Macroeconomic Analysis (3)	
Eco 229	Money and Banking (3)	
Eco 339, 340	International Trade and Finance (6)	

Public Administration Option

Acctg 51	Essentials of Accounting (3)	*or*
Acctg 108	Fundamentals of Accounting (3)	
IR 353	International Institutions	*or*
IR 361	International Law (3)	
Eco 353	Public Finance (3)	
Govt 360	Public Administration (3)	
Govt 363	Contemporary Political Philosophy (3)	*or*
Govt 364	Issues in Contemporary Political Philosophy	
Govt 322	Politics of Developing Nations (3)	

Open Option

In place of any of the options, a student may take an open option by meeting the advanced course requirements for one of the other College of Arts and Science major subjects. The open option is most feasible with humanities and social science majors but requires a careful combining of distribution courses and free electives with the eighteen hours normally given to the option. Students interested in the open option should consult the director of the foreign careers major early in the university career.

Foreign Languages

The reader is referred to course descriptions under Modern Foreign Languages.

French

The reader is referred to course descriptions under Modern Foreign Languages.

Fundamental Sciences

Curtis W. Clump, associate dean of the College of Engineering and Physical Sciences, and *director of the fundamental sciences program*

The curriculum in fundamental sciences is designed to enable students to achieve a breadth of academic background in the fields of modern science and at the same time, through an option, to master the discipline of one of them, approximately to the level of a minimum bachelor's program. The options and electives provide sufficient flexibility to enable a student to prepare for employment in industry or government, or approach adequacy for graduate study in a field.

The program offers an opportunity for students who are uncertain of their desire for a career in a particular field to proceed on a broad program which can lead to a bachelor's degree. If the student's interest crystallizes in an established field, transfer to that major will normally be possible with only a minimum of dislocation, especially if the student has completed the introductory courses in that field.

Fundamental science students are required to concentrate in a major. Students can organize acceptable programs including the substantive course elements related to any one among several areas such as chemistry, physics and mathematics, biology, earth and space science, science of living systems, materials, computer science, and architecture, or meaningful combinations of any two.

The freshman year is identical with that of all students in the College of Engineering and Physical Sciences. The General Studies requirements of the college must also be satisfied. The discipline of a field will be provided by the inclusion of at least fifteen semester hours or from a combination which constitutes the core of one of the combination fields. Examples of these combination majors include: biochemistry, geophysics, bioengineering, applied mathematics, ocean engineering, and computer science. Students pursuing double concentrations may, with the approval of their adviser, substitute for one of the science courses of the sophomore year a basic course in the area of concentration.

The details of the student's program are worked out by the student with the advice of the curriculum adviser, and with the approval of the department chairmen concerned with the fields of concentration.

freshman engineering year (see page 43)

sophomore year, first semester (15-16 credits)

Biol 21, 22	Principles of Biology and Lab (4)	*or*
Geol 1	Principles of Geology (3)	
Chem 51, 53	Organic Chemistry and Laboratory (4)	
Math 23	Analytical Geometry and Calculus III (4)	
Eco 1	Economics (4)	

sophomore year, second semester (17 credits)

	major subject (3)
	approved elective (3)
Math 205	Linear Methods (3)
Phys 21, 22	Introductory Physics II and Laboratory (5)
	General Studies elective (3)

junior year, first semester (15-16 credit hours)

Geol 1	Principles of Geology (3)	*or*
Biol 21, 22	Principles of Biology and Laboratory (4)	
Psych 1	Introduction to Psychology (3)	
Math 231	Probability and Statistics (3)	
	major (3)	
	General Studies elective (3)	

junior year, second semester (15 credit hours)

approved electives (6)
major (6)
elective (3)

senior year, first semester (15-18 credit hours)

approved electives (6)
major (6)
General Studies elective (3)
elective (0-3)*

senior year, second semester (15-18 credits)

Phil 42	The Scientific Process (3)
	approved elective (3)
	major (6)
	General Studies elective (3)
	elective (0-3)*

*Please refer to description of normal program, page 43.

Geological Sciences

Professors. Charles B. Sclar, Ph.D., *chairman*; James M. Parks, Ph.D., director, Center for Marine and Environmental Studies; Adrian F. Richards, Ph.D.; J. Donald Ryan, Ph.D.; Dale R. Simpson, Ph.D.
Associate professors. Bobb Carson, Ph.D.; Paul B. Myers, Jr., Ph.D.
Assistant professors. Edward B. Evenson, Ph.D.; Kenneth P. Kodama, Ph.D.

Geology, and related sciences such as geophysics and geochemistry, deal with natural phenomena on or within the earth. Each is a science which makes use of other more fundamental sciences in its practice; hence, the student preparing for a career in one of the geological sciences combines study in geology with a broad understanding of physical, chemical, and biological principles.

Lehigh offers two undergraduate programs in geological sciences, one leading to the degree of bachelor of science in geological sciences, the other to the degree of bachelor of arts. The bachelor of science curriculum is considered to be the professional route. The bachelor of arts program requires fewer credits for graduation (121 vs. 127 credit hours), fewer courses in collateral sciences and mathematics (34 vs. 37 credit hours), and fewer geology courses (32 vs. 42 credit hours). Candidates for the bachelor of science degree also are required to take fifteen credit hours in approved professional electives. The professional electives permit the student to arrange for an informal option in geophysics, geochemistry, engineering geology, etc.

Students electing the bachelor of arts program are required to meet the distribution requirements of the College of Arts and Science; candidates for the bachelor of science degree take thirty credit hours of nonprofessional electives in place of the distribution requirements. There is no foreign language requirement in either program. However, it is strongly recommended that all students who plan to attend graduate school and who have not previously studied either French, German or Russian, include courses in one of these languages in their undergraduate program.

Attendance at an approved summer geology field camp is required in both programs.

Both the bachelor of science program and the bachelor of arts program provide preparation for graduate school. Qualified students may be given permission at the end of the junior year to enter a program wherein they are able to begin work toward a graduate degree during the senior year. See Combined B.A. or B.S. and M.S. program below.

Geological training may be utilized in industry (especially in the petroleum, mining, highway construction, ceramics, and metallurgical industries), government service, natural resource management, and in secondary school and college teaching. Students planning on careers in industry are advised to register for the bachelor of science program.

A major in geophysics is offered with faculty from cooperating departments. This program is described under "Geophysics."

Bachelor of Science in Geological Sciences

One-hundred and twenty-seven credit hours are required.

college and university requirements (36 credit hours)
Engl 1 Composition and Literature (3)
Eng 2, 10, 14, or 16 Composition and Literature (3)
electives (30 credit hours)

Elective courses are nonprofessional courses designed to give the student a broad understanding in traditional and contemporary fields of thought outside of natural science and mathematics. The courses are chosen by the student. The elective program includes a large number of courses broadly distributed among the various areas of the humanities and the social sciences.

the major program (91 credit hours)

mathematics (12 credit hours)
Math 21 Analytic Geometry and Calculus I (4)
Math 22 Analytic Geometry and Calculus II (4)
Math 23 Analytic Geometry and Calculus III (4)

collateral sciences (22 credit hours)
Chem 21, 22 Introductory Chemical Principles and Laboratory (5)
Chem 31 Chemical Equilibria in Aqueous Systems (3)
Phys 11, 12 Introductory Physics I and Laboratory (5)
Phys 21, 22 Introductory Physics II and Laboratory (5)
Biol 21, 22 Principles of Biology and Laboratory (4)

geology (42 credit hours)
Geol 1 Principles of Geology (3)
Geol 2 Introductory Geology Laboratory (1)
Geol 10 Computer Applications (1)
Geol 12 Historical Geology (3)
Geol 23 Structural Geology (3)
Geol 33 Introductory Mineralogy and Petrology (3)
Met 210 Metallurgical Thermodynamics (3) *or*
Chem 187 Physical Chemistry (3)
Geol 301 Introduction to Geophysics (3)
Geol 311 Paleontology (3)
Geol 312 Geomorphology (3)
Geol 313 Sedimentology (3)
Geol 333 Crystallography (3)
Geol 334 Petrology and Petrography (4)
Geol 341 Field Geology (6)

approved professional electives (15 credit hours)
Courses approved to fulfill this requirement should form a coherent package supporting the professional objectives of the student. Examples of coherent groups of recommended courses that may serve to fulfill this requirement are as follows:
Geol 336 Mineral Phase Relations (3)
Geol 337 X-ray Methods (3)
Geol 338 Electron Metallography (4)
Geol 357 Economic Geology (3)
Geol 372 Principles of Geochemistry (3)

2) Geol 314 Glacial and Quaternary Geology (3)
Geol 319 Regional Stratigraphy (3)
Geol 321 Statistical Applications (3)
Geol 327 Genesis of Carbonate Rocks—I (1)
Geol 328 Genesis of Carbonate Rocks—II (2)
Geol 397 Soil Genesis (3)

Other coherent groups of courses which meet the specific objectives of the individual student may be selected with the approval of the faculty adviser.

B.A. With Geology Major

One-hundred and twenty-one credit hours are required.

college and university requirements
Engl 1 Composition and Literature (3)
Engl 2, 10, 14 or 16 Composition and Literature (3)
distribution requirements (see page 36)

the major program (66 credit hours)

mathematics (12 credit hours)
Math 21 Analytic Geometry and Calculus I (4)
Math 22 Analytic Geometry and Calculus II (4)
Math 23 Analytic Geometry and Calculus III (4)

collateral sciences (22 credit hours)
Chem 21, 22 Introductory Chemical Principles and Laboratory (5)
Chem approved elective (3)
Phys 11, 12 Introductory Physics I and Lab (5)
Phys 21, 22 Introductory Physics II and Lab (5)
Biol 21, 22 Principles of Biology and Laboratory (4)

geology (32 credit hours)

Geol 1	Principles of Geology (3)
Geol 2	Introductory Geology Laboratory (1)
Geol 10	Computer Applications (1)
Geol 12	Historical Geology (3)
Geol 23	Structural Geology (3)
Geol 33	Introductory Mineralogy and Petrology (3)
Geol	approved electives (12)
Geol 341	Field Geology (6)

Combined B.A. or B.S. and M.S. Program in Geological Sciences

The department of geological sciences offers a combined bachelor of arts or bachelor of science and master of science program. Students working toward the bachelor of arts or the bachelor of science in geological sciences who are enrolled in this program are permitted to take courses which apply toward the master of science degree during their senior year. During the student's senior year, the normal undergraduate tuition will cover the costs of all courses taken including those which are taken for graduate credit.

After receiving the bachelor's degree, students registered in the program may acquire, if eligible for admission to the graduate school, full-time graduate status, and, as such, they may apply for appointment to a teaching assistantship, research assistantship, or graduate fellowship.

The program is designed for those students who, upon completing the junior year and the field camp requirement, need less than thirty credit hours to complete work for the bachelor's degree. To be accepted into the program, students should have a superior record of academic performance.

Application for admission to the program should be made no later than the beginning of the first semester of the senior year and must be approved by the department faculty and the dean of the Graduate School. The application must include: 1. a tentative master of science program approved by the department chairman, and 2. a roster, also approved by the department chairman, showing which courses taken during the senior year apply toward the bachelor's degree and which courses apply toward the master's degree. No more than fifteen credit hours per semester may be rostered. A total of 151 credit hours are required for the combined bachelor of arts — master of science program and a total of 157 credit hours are required for the combined bachelor of science — master of science program. All of the normal requirements for each degree as outlined must be fulfilled.

Students enrolled in this program should make application for admission to full-time graduate status after completing the first semester of the senior year.

Program in Geological Engineering

The department of geological sciences, in conjunction with the department of civil engineering, administers a five-year program in geological engineering which leads to a bachelor of science degree in civil engineering and a bachelor of science degree in geological sciences. This is described in this section under Five-Year Programs.

Undergraduate Courses

1. Principles of Geology (3) fall-spring
Fundamental concepts of geology; the composition, structure, and development of the earth; processes of geological change. Lectures and field trip.

2. Introductory Geology Laboratory (1) fall-spring
Recommended laboratory given concurrently with Geol 1. Study of rocks and minerals, rock structures, land forms. Prerequisite: Geol 1 previously or concurrently.

10. Computer Applications (1) fall
The use of computers in the solution of geological problems. Introduction to Fortran; the use of published and available programs. Parks

12. Historical Geology and Stratigraphy (3)
Origin and evolution of the earth and its parts: continents, ocean basins, hydrosphere, and atmosphere; origin and evolution of life. Stratigraphic correlation, facies change, breaks in the record, paleogeographic and paleoenvironmental reconstruction. Prerequisite: Geol 1 or 101. Ryan

23. Structural Geology (3) spring
The application of basic concepts of stress and strain and experimental data to study of the developments of faults, folds, and other deformational structures in the earth's crust. Introduction to the larger-scale problems of geotectonics. Prerequisite: Geol 1 or 101. Myers

33. Introductory Mineralogy and Petrology (3) fall
Principles of crystallography, mineralogy, and petrology; megascopic study, identification, and description of common minerals and rocks. Lectures and laboratory. Prerequisites: Geol 1 or 101, Chem 21. Sclar

63. Introduction to Oceanography (3) spring
A survey of the physical, chemical, biological, and geological nature of the oceans. Prerequisite: one year of science (biology, chemistry, geology or physics). Carson

81. Aerial Photo Interpretation (1) spring
Use of aerial photographs and space imagery to obtain qualitative and quantitative terrain information. Applications in geology, ecology, engineering, land planning. Ryan

97. Man-Ocean Interaction (3) fall
An introduction to the science of oceanography with an assessment of selected global problems, including energy extraction, climate modification, nodule mining, and pollution. Richards

101. Geology for Engineers (3) fall
A study of the materials which make up the earth, the physical, chemical, and environmental history that they relate, and the processes that act to change them. Designed primarily for upperclass science and engineering majors. Lectures and laboratory-recitation. Myers

191. (Biol 191) Environmental Science Seminar (1)
Seminar on current problems and developments in environmental science. May be repeated for credit. Prerequisite: sophomore standing. Evenson, Bell

211. Environmental Geology (3) fall
Analysis of the dynamic interaction of geologic processes and human activities. Catastrophic geologic processes, resource limitations and development, pollution of geologic systems, environmental legislation, engineering case studies. Evenson

281. Geological Research (1-6) fall
Independent investigation of a special problem in the field, laboratory, or library. Prerequisite: consent of the chairman.

282. Geological Research (1-6) spring
Similar to Geol 281. May be elected as a continuation or separately. Prerequisite: consent of the department chairman.

For Advanced Undergraduates and Graduate Students

301. Introduction to Geophysics (3) fall
Application of physical principles to solution of crustal and near-surface geologic problems: reflection and refraction seismology, gravity, magnetic and electrical methods. Prerequisites: Math 21, Phys 21, and Geol 1 or 101. Kodama

302. Physics of the Earth (3) spring
Application of physical principles to the earth: origin, geochronology, heat generation and flux, seismology, gravity, magnetism and tectonics. Prerequisites: Math 21, Phys 21. Kodama

306. Geophysical Field Techniques (3) spring
Geophysical field investigation in an area of geological interest.

Theory and application of seismic, gravity, magnetic, and electrical methods; data collection, interpretation, and a written report. Individual assignments of a geophysical field in an area of geological interest. Prerequisite: Geol 301 or consent of department chairman. Kodama

311. Paleontology (3) spring
Morphology of invertebrate fossils, their use in interpreting geologic history; evolution of the faunas and floras. Lectures and laboratory work. Prerequisite: Biol 21. Parks

312. Geomorphology (3) spring
Systematic study of the origin, evolution, and distribution of the earth's topographic features. Land forms analyzed in terms of chemical and physical processes responsible for their development. Lectures and required field trips. Prerequisite: Geol 1 or 101. Evenson

313. Sedimentology (3)
The processes that control weathering, transportation, and deposition of sediments; the characteristics of sediments and environments of deposition. Lectures and laboratory. Prerequisite: Geol 333. Carson

314. Glacial and Quaternary Geology (3) spring
Study of the origin, distribution, and movement of present and past glaciers. Special emphasis on glacial land forms and deposits, quaternary stratigraphy and dating techniques, periglacial phenomena, and Pleistocene environments. Lectures and required field trips. Prerequisite: Geol 1 or 101. Evenson

315. Coastal Sedimentation (1)
Origin, dispersal, and deposition of clastic sediments in the shore zone with emphasis on the barrier beach-salt marsh complex. Lectures and laboratory conducted at The Wetlands Institute. Not offered on a regular basis. Prerequisite: consent of the chairman.

317. (Biol 317) Evolution (3)
The origin of species and higher categories with emphasis on animals. Isolating mechanisms, population structure, rates of evolution, extinction. Prerequisite: two semesters of biology or consent of department chairman. Barber

319. Regional Stratigraphy (2) spring
Studies of sedimentary rock sequences in North America illustrating principles of correlation, facies change, methods of environmental and paleogeographic reconstruction. Ryan

320. Advanced Computer Applications (1-3)
Independent investigation of special problems utilizing computer techniques. Prerequisite: Geol 10 or consent of the department chairman. Parks

321. Statistical Applications (3) fall
Statistical models applicable to geological, geochemical, and geophysical field and laboratory studies. Analysis of variance, applications of the chi-square distribution, analysis of covariance, linear, nonlinear and multiple regression, and distribution-free methods. Carson

323. Geophysics of Plate Tectonics (2)
Seminar on geophysical topics in plate tectonics: geometry, seismology, magnetism, gravity, driving mechanism, and heat flow. Prerequisites: Geol 23 and Phys 21. Kodama

327. Genesis of Carbonate Rocks I (1) fall
Seminar on the geology and biology of modern and ancient carbonate environments: biology and ecology of major carbonate producing organisms; origin, deposition, lithification and classification of carbonate sediments. Student-faculty seminars and discussions. Evenson, Parks

328. Genesis of Carbonate Rocks II (2) spring
Field studies carried out in intersemester period (january) in Florida Keys on modern and ancient carbonate environments: ecology and geology of reef-building corals, calcareous algae, and other carbonate-producing organisms in beach, reef, lagoonal, and traditional environments. Team research projects and reports. Evenson, Parks

333. Crystallography (3) fall
Fundamentals of crystallography and crystal structure; patterns and symmetries, symmetry notations, crystal morphologies and internal structure, principles of crystal chemistry. The anisotropy of crystalline materials with speical reference to crystal optics. Lectures and laboratory. Prerequisite: Geol 33, previously or concurrently. Simpson

334. Petrology and Petrography (4) fall
Evolution of rocks and their distribution in space and time; Microscopic study of rocks. Lectures, laboratory work, and field trips. Prerequisite: Geol 333. Myers

336. Mineral Phase Relations (3) spring
Principles of phase equilibria; unicomponent and multicomponent condensed systems and multicomponent systems with volatile phases. The application of phase relation studies to mineralogical and geological problems. Prerequisite: Geol 333. Lectures and laboratory. Simpson

337. (Met 333) X-ray Methods (3) fall
Fundamentals and experimental methods of X-ray techniques. Application to various materials problems including diffraction, radiography, fluorescent analysis. Lectures and laboratory work. Prerequisite: Phys 21, Met 91 or equivalent. Kraft

338. (Met 334) Electron Metallography (4) spring
Fundamentals and experimental method of one or more of the electron beam techniques. Specific topics include electron optics, electron beam interactions with solids, electron diffraction, chemical microanalysis, scanning electron microscopy, conventional transmission and scanning electron microscopy. Applications to the study of the structure of materials are given. Special laboratories are given in cooperation with other departments as required. Prerequisite: consent of the department chairman. Williams, Goldstein

341. Field Geology (6) summer
Field study and geologic mapping of sedimentary, igneous-metamorphic, and glacial deposits in the Rocky Mountains of northwestern Wyoming, and southeastern Idaho. Additional short studies in the Badlands and Black Hills of South Dakota, the Grand Tetons, Yellowstone Park, Craters of the Moon Park, and other areas in the Rocky Mountain region. Six weeks in the field. Summer session. Prerequisite: consent of the department chairman. Evenson, Myers

342. Advanced Glacial Geology (3)
Seminar on advanced topics in glacial geology; review of classic and contemporary literature. Topics include dynamics of glacier movement, glacial landforms and deposits, glacial stratigraphy. Field trips. Prerequisite: Geol 314 or consent of the department chairman. Evenson

344. Advanced Geomorphology (3)
Seminar on advanced topics in geomorphology. Field trips. Prerequisite: Geol 312 or consent of the department chairman. Evenson

351. Petroleum Geology (3)
Origin, migration, and accumulation of petroleum and natural gas; general principles of exploration and production. Prerequisites: Geol 23 and Geol 313 previously or concurrently. Parks

352. Applied Mineralogy (3)
Methods and approaches to the solution of industrial and environmental problems employing modern mineralogical techniques, especially transmitted- and incident-light polarizing microscopy and X-ray powder diffraction. Case histories of interest to geologists, chemists, ceramists, chemical, metallurgical, and mineral engineers, environmental engineers, and materials scientists. Lectures and laboratory. Prerequisite: Geol 333 or consent of the department chairman. Sclar

356. Ground Water (3)
The geology and geochemistry of ground water. Techniques used in prospecting for ground water, ground water law, management and conservation, evaluation and planning. Prerequisites: Chem 21, 22, Geol 23. Myers

357. Economic Geology (3) spring
The formation of mineral deposits and the occurrence and characteristics of deposits of economic importance. Includes metals, nonmetals and fuels. Lectures, laboratory work and inspection trips. Prerequisite: Geol 1. Simpson

372. Principles of Geochemistry (3) spring
Synthesis of the geological, chemical, physical, and astronomical observations regarding the geochemical evolution of the earth, its internal constitution, and the physico-chemical processes which modify the crust. Crystal-chemical controls on the abundance and distribution of the chemical elements. Experimental high-pressure studies of geochemical significance. Shock metamorphism as a geochemical process on the surface of the earth, moon and planets. Sclar

397. Soil Genesis (3)
A geologic approach to the genesis, classification and applications of pedology. Weathering of parent materials; chemistry of soils; geologic, biologic, and climatic controls on soil formation; geologic and engineering geologic applications of soils. Field and laboratory investigations will acquaint the student with modern analytic techniques. Two lectures and one laboratory/discussion per week. Prerequisites: Geol 313 or consent of the department chairman. Evenson, Carson, Myers

For Graduate Students

The graduate program in geological sciences is mainly directed toward the study of geologic processes. Candidates for the master's degree receive instruction in most fields of geology and are expected to take courses in appropriate collateral fields of science. Advanced graduate students, working toward the doctorate, specialize in one field of geology.

Research is an important part of the graduate program. In general, students are encouraged to choose research problems which for their solution require the use of integrated laboratory and field studies.

Candidates for the master of science degree are required to complete a thesis (six credit hours) which must be presented in the form specified by the Graduate School. The research and writing of the thesis will be done under the direction of the thesis director who must be a member of the faculty of the department. The thesis director and two other members will constitute the thesis committee for the master of science candidate. Students who enter the graduate program with a Bachelor of Science or Bachelor of Art in geology and who wish to qualify for admission to candidacy for the Doctor of Philosophy degree must take the departmental qualifying examination prior to the end of the fourth semester. Those prior to the end of their fourth semester. Those who enter the program with Master of Science degree must take the qualifying examination prior to the close of their second semester. Candidates entering the program from a discipline other than geoscience will be advised by the faculty when to take the qualifying examination.

Candidates for the doctor of philosophy degree must demonstrate thorough examination a thorough reading knowledge of one foreign language, generally French, German or Russian.

Other requirements for graduate degrees are listed in the Graduate School section.

Special departmental research facilities of interest include: Norelco X-ray source, diffractometer, and powder cameras, complete petrographic and incident-light microscopy facilities, hydrothermal apparatus for experimental mineralogy, belt-type ultra-high-pressure apparatus for upper mantle studies, soft-sediment deformation apparatus, carbon-hydrogen analyzer, Sharples supercentrifuge, Worden gravimeter, Geometrics portable proton magnetometer, Saltzman map projector, standard equipment for field mapping, a completely equipped maring geotechnical laboratory, and a Smit portable core drill.

The following major analytical facilities are available on campus to students and staff of the department: fully automated ARL electron microprobe, Philips 300 electron microscope completely equipped for transmission and diffraction, ETEC scanning electron microscope with nondispersive analysis capability, and Perkin Elmer automated double-beam infrared spectrophotometer.

405. The Earth's Magnetism (3)
Terrestrial magnetism, rock magnetism, history of the geomagnetic field, spherical harmonics, and the interpretation of magnetic anomalies. Prerequisite: Phys 21. Kodama

407. Seismology (3)
Basic seismological concepts: design and characteristics of seismometers; interpretation of seismograms; ray paths, body and surface waves, surface wave dispersion, earth structure, and free oscillations of the earth. Prerequisites: Math 23 and Phys 21. Kodama

411. Advanced Paleontology (3)
Classification, evolution, biometrics and paleoecology; study of fossil and modern populations and assemblages. Lectures and laboratories. Prerequisite: Geol 311. Parks

413. Advanced Topics in Sedimentology (1-3)
Study of the origin, dispersal, deposition, and diagenesis of sediments and sedimentary rocks. May be repeated for credit. Prerequisite: Geol 313. Carson

417. Sedimentary Petrography (3)
The theory and application of petrographic methods in the study and classification of sedimentary rocks. Prerequisite: Geol 334. Ryan

418. Sedimentary Petrogenesis (3)
The origin and development of sedimentary rock types; mineral provenance, environment of deposition, diagenesis, sediments in time, stratigraphic synthesis. Prerequisite: Geol 417. Ryan

419. Sedimentary Basin Analysis (1)
Seminar on the use of directional features, petrographic variations, and other primary physical properties of sedimentary rock which make possible reconstruction of ancient sedimentary basins and sedimentary dispersal systems within such basins. May be repeated for credit. Ryan

421. Global Tectonics (3) fall
Topics include upper mantle composition and configuration, interrelations between the earth's crust and upper mantle, geophysical data related to hypotheses in global tectonics, continental drift and the plate model. Seminars and lectures. Myers

422. Regional Tectonics (3) spring
Concepts of global tectonics as applied to the geology of specific areas of the earth's crust. The tectonics of the Alpine-Himalayan chain, Rockies, Caledonides, Appalachian, coast ranges, and African Rift system are among subjects considered. Seminars and lectures. Myers

423. Sedimentary Geochemistry (3)
Processes controlling the distribution of elements in sediments and sedimentary rocks. Lectures, discussions, occasional laboratory exercises, and field trips. Ryan, Simpson

424. Advanced Structural Geology (3) alternate years
The theory and application of analytical methods in the study of rock deformation; experimental deformation, petrofabric analysis; statistical field methods. Myers

425. Seminar on Tectonics (1)
Seminar on contemporary topics in tectonics. May be repeated for credit. Myers

435. Advanced Mineralogy (3)
Topics of contemporary interest in mineralogy. Simpson

436. Advanced Mineralogy (3) offered as required
Similar to Geol 435. May be elected separately. Simpson

437. Advanced Igneous Petrology (3) alternate years
Origin of the diversity of igneous rocks as revealed by field and laboratory studies. Lectures, laboratory and field trips. Sclar

438. Advanced Metamorphic Petrology (3) alternate years
Processes involved in the transformation of rock masses under high pressure and temperature. Problems of the deep crust and upper mantle. Lectures, laboratory and field trips. Sclar

439. Seminar on Petrology (1)
Critical review and assessment of current literature on major topics in petrology. May be repeated for credit. Sclar

444 (Biol 444) Multivariate Analysis (3)
The strategy of the application of multivariate analysis techniques to problems in geology and biology. Analysis of large data matrices by factor analysis, cluster analysis, discriminant function analysis, ordination and related techniques. Examples from both geology and biology. Prerequisites: Geol 10 and 321 or approved equivalents. Parks, Carson

454. Genesis of Metalliferous Deposits (3) alternate years
Petrological concepts regarding the origin of metalliferous ore deposits. Laboratory includes ore-mineral synthesis, ore microscopy, and electron microprobe analysis of ores. Field examination of ore deposits at operating mines. Sclar

456. Advanced Topics in Economic Geology (3)
Modern concepts bearing on the nature and origin of ore deposits. Lectures, seminars, field trips. Simpson

461. Marine Geology (3) alternate years
Geology of the margins and the floors of the oceans. Carson

462. Paleoecology (3) alternate years
Reconstruction of paleoenvironments based on principles of paleoecology and sedimentary petrology. Prerequisites: Geol 311 and 313. Parks

471. High-Pressure Petrology (3)
High-pressure phase transformations, phase equilibria, and melting phenomena in multicomponent systems of petrological importance as applied to problems of the deep crust and upper mantle in the pressure range 15 to 150 kilobars at temperatures to 1500 degrees C. Effect of water as a free phase at high pressure. Lectures and laboratories. Sclar

472. Solution Geochemistry (3)
The processes of solution, transport, and deposition under hydrothermal conditions. Simpson

480. (Biol 480) Marine Science Seminar (1)
An advanced interdisciplinary seminar on various problems of marine sciences, with visiting speakers and student presentations.

481. Geological Investigation (1-6) fall-spring
Research on a special problem; field, laboratory, or library study; report required. Credit above three hours granted only when a different problem is undertaken.

482. Geological Investigation (1-6) fall-spring
Similar to Geol 481. Credit above three hours granted only when a different problem is undertaken.

490. Special Topics (1-6)
An extensive study of topics not covered in more general courses.

491. Special Topics (1-6)
Similar to Geol 490. May be elected separately.

Geophysics

Kenneth P. Kodama, *director* and assistant professor of geophysics.

Geophysics is the branch of the earth sciences in which physical principles are used to understand the subsurface geology and history of the earth. Geophysical methods are important in the search for energy and mineral resources. The program is designed to provide the background needed for graduate work in geophysics or the preparation for employment in the petroleum and mineral industries.

Bachelor of Science Degree

One-hundred-twenty-six credit hours are required.

college and university requirements (36 credits)

Engl 1	Composition and Literature (3)
Engl 2, 10, 14, 16	(3)
	electives (30 credit hours)

Elective courses are nonprofessional courses designed to give the student a broad understanding in traditional and contemporary fields of thought outside of natural science and mathematics. The courses are chosen by the student. The elective program includes a large number of courses broadly distributed among the various areas of the humanities and the social sciences.

The major program (90-95 credit hours)

mathematics (18 credit hours)

Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry and Calculus II (4)
Math 23	Analytic Geometry and Calculus III (4)
Math 205	Linear Methods (3)
Math 322	Methods of Applied Analysis I (3)

collateral sciences (eight credit hours)

Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
Met 210	Metallurgical Thermodynamics (3)

physics (20 credit hours)

Phys 11	Introductory Physics I (4)
Phys 12	Introductory Physics Laboratory I (1)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
Phys 90	Electronics (1)
Phys 212	Electricity and Magnetism I (3)
Phys 213	Electricity and Magnetism II (3)
Phys 215	Particles and Fields I (3)

geology (32 credit hours)

Geol 1	Principles of Geology (3)
Geol 2	Introductory Geology Laboratory (1)
Geol 10	Computer Applications (1)
Geol 12	Historical Geology (3)
Geol 23	Structural Geology (3)
Geol 33	Introductory Mineralogy and Petrology (3)
Geol 301	Introduction to Geophysics (3)
Geol 302	Physics of the Earth (3)
Geol 313	Sedimentation (3)
Geol 333	Crystallography (3)
Geol 341	Field Geology (6)

approved professional electives (12-17 credits)
Any courses approved by the adviser may be used to satisfy this requirement. The following are especially recommended:

Chem 31	Chemical Equilibria in Aqueous Systems (3)
Geol 63	Introduction to Oceanography (3)
Geol 306	Geophysical Field Techniques (3)
Geol 319	Regional Stratigraphy (3)
Geol 321	Statistical Applications (3)
Geol 334	Petrology and Petrography (4)
Geol 336	Mineral Phase Relations (3)
Geol 372	Principles of Geochemistry (3)
Geol 381	Meteorology (3)
Math 323	Methods of Applied Analysis (3)
Math 105	Computer Programming (3)
Math 208	Complex Variables (3)
Math 309	Theory of Probability (3)
Math 310	Probability and its Applications (3)
Math 302	Vector and Tensor Analysis (3)
Math 366	Programming Techniques (3)

ME 231	Fluid Mechanics (3)
Met 91	Elements of Materials Science (3)
Phys 31	Introduction to Quantum Mechanics (3)
Phys 191	Laboratory Techniques (2)
Phys 216	Particles and Fields II (3)
Phys 340	Thermal Physics (3)
Phys 352	Modern Optics (3)
Phys 254	Optics Laboratory (2)
Phys 363	Physics of Solids (3)
Phys 365	Physics of Fluids (3)

German

See listings under Modern Foreign Languages.

Government

Professors. Donald D. Barry, Ph.D., *chairman*, until June 30, 1979 (on leave, spring, 1980); Charles A. McCoy, Ph.D.; W. Ross Yates, Ph.D.
Associate professors. Frank T. Colon, Ph.D., (on leave, spring, 1979); Howard R. Whitcomb, Ph.D., *chairman*, effective July 1, 1979.
Assistant professors. Carol Barner-Barry, Ph.D.; Laura Katz Olson, Ph.D.; Edward P. Morgan, Ph.D.

The major in government is designed to promote understanding of political ideas, institutions and processes and to develop skills in analyzing and evaluating political problems.

These goals can best be achieved when a student is enabled to assume a large measure of responsibility for his or her own education. The student should be free to study in either structured or unstructured ways. The government department curriculum is designed so that the undergraduate can develop, with the approval of an adviser, a plan of course study in line with his or her interests, concerns and knowledge.

A balanced program within the discipline, one which exposes the student to various areas of inquiry in American institutions and political processes as well as in the comparative and philosophical perspectives of political analysis, has been the way in which the goals of the major program generally have been achieved. While the major program outlined below will prove adequate for most student needs, it may be that because of some special factors such as late transfer or unusual interests and/or abilities the outlined program does not accommodate some students. In that case the students may, in consultation with their adviser, develop a major program which in their judgment will more adequately fulfill those needs.

The faculty adviser to the student majoring in the government department is designated by the department. The adviser consults with the student and approves the major program. The adviser attempts to help the student relate courses offered by the department to the student's educational goals. The adviser also may act as a resource for the student, and may suggest courses in other disciplines, language courses, and courses in research techniques which may be of benefit.

Completion of the government major is considered suitable training for the undergraduate who wishes to go on to law school, to become a social science teacher, or to work as a governmental official, party or civic leader, public affairs commentator or staff member of a government research bureau. Graduate study is advisable for students contemplating certain careers—college teaching, research, or public management, for example.

The four core courses are required. Individual exceptions may be made, for good reasons, by the major adviser with the approval of the department chairman.

Core Courses

Govt 1	American Political System (3)
Govt 3	Comparative Politics (3)
Govt 21	Introduction to Political Research (3)
Govt 102	Modern Political Heritage (3)

Electives
Seven elective courses with at least two courses from each of the following two fields: American politics, public law and interdisciplinary

Govt 53	Law and Politics (3)
Govt 74	Political Parties and Elections (3)
Govt 77	Urban Politics (3)
Govt 79	The Politics of Women (3)
Govt 302	Comparative State Politics (3)
Govt 306	Public Policy Process (3)
Govt 317	The American Presidency (3)
Govt 327	Socialization and the Political System (3)
Govt 328	The Politics of Urban Policy (3)
Govt 331	Internship Seminar (3)
Govt 333	The Social Psychology of Politics (3)
Govt 351	Constitutional Law (3)
Govt 352	Civil Rights (3)
Govt 354	Administrative Law (3)
Govt 355	Public Personnel (3)
Govt 357	Technology Assessment (3)
Govt 359	The Legislative Process (3)
Govt 360	Public Administration (3)
Govt 361	Field Research (3)

Political theory and comparative politics

Govt 61	The Soviet Political System (3)
Govt 71	Democracy (3)
Govt 101	Classical Political Heritage (3)
Govt 106	The Chinese Political System (3)
Govt 301	International Policy-Making (3)
Govt 305	The Dynamics of Regional Integration (3)
Govt 308	Ideologies in World Affairs (3)
Govt 318	Communist Political Systems (3)
Govt 322	Politics of Developing Nations (3)
Govt 324	Political Systems in Transition (3)
Govt 363	Contemporary Political Philosophy (3)
Govt 364	Issues in Contemporary Political Philosophy (3)
Govt 365	Political Values of Neo-Freudians and Existentialists (3)
Govt 368	Political Economy (3)

Government Minor

The minor consists of three of the four core courses listed above (Govt 1, Govt 3, Govt 21 and Govt 102) plus any two other government courses.

Public Administration Minor

The minor consists of Govt 1 and Govt 360 plus four other courses chosen in consultation with the adviser for a total of eighteen credit hours.

Undergraduate Courses

Govt 1 and Govt 3 are considered preliminary courses. All other courses below the 300 level can be used to satisfy both preliminary and upperclass requirements. Courses at the 300 level satisfy only upperclass requirements.

1. American Political System (3) P fall-spring
Constitutional principles; organization and operation of the national government; the party system, citizenship, and civil rights.

3. Comparative Politics (3) P fall-spring
The political systems of foreign countries; approaches to the study of comparative politics.

21. Introduction to Political Research (3)
The research techniques of political science including research design, statistical and nonstatistical analysis, and computer applications.

53. Law and Politics (3)
A focus on the relationship between politics and the law. Selected issues such as the role of the legal profession, civil and criminal justice, plea-bargaining and political trials will be treated. The case method is not used.

61. The Soviet Political System (3) spring
The roles of the Communist Party, the Council of Ministers, the Supreme Soviet and other governmental and social organizations in governing the USSR. Barry

71. Democracy (3)
Theory and practice of democratic government in selected countries. Prerequisite: sophomore standing. Yates

74. Political Parties and Elections (3)
Organization, functions, and behavior of parties in the United States; voting behavior, campaigns, and elections.

77. Urban Politics (3)
The structure and processes of city government in the United States; city-state and federal-city relationships; the problems of metropolitan areas; political machines and community power structures; the urban politics of municipal reform; city planning and urban renewal.

79. The Politics of Women (3)
Major social and political issues relating to the role of women in American society. Study of other countries will be included for comparative analysis. Olson

101. Classical Political Heritage (3)
Significant political theorists from Plato to modern times.

102. Modern Political Heritage (3)
Continuation of Govt 101, Classical political heritage. Utilitarianism, liberalism, socialism, idealism, positivism, etc.

106. The Chinese Political System (3)
Revolutionary origins of the Chinese political system. Roles of the state, structure, Communist Party, army, mass organizations, and political campaigns in the political decision-making and policy implementation processes. Nature and function of Chinese political ideology.

For Advanced Undergraduates and Graduate Students

301. (IR 301) International Policy-Making (3)
Policy-making processes in the contemporary world; impact of assumptions and projections of future social and technological change on international decisions. Prerequisite: IR 1 or 2 or consent of the department chairman. Slouka

302. Comparative State Politics (3)
Analysis of major questions relating to the role of the states in the American federal systems and their relationship with the national government. Colon

305. (IR 305) Dynamics of Regional Integration (3)
Theories of regional integration; supernational community-building in West Europe, North Atlantic area, and developing countries in Latin America, Asia and Africa. Hodges

306. Public Policy Process (3)
Power relations and their impacts on selected public policy issues, specifically taxation, housing, environment, poverty, energy, the military, and health. Olson

308. (IR 308) Ideologies in World Affairs (3)
Theories of ideology; nationalism and imperialism; conservatism/liberalism/socialism; Marxism/Leninism/Maoism; fascism and militarism; Third World ideologies; current ideological trends. Wylie

313. Teaching Government (3)
Contemporary issues in the teaching of social studies in public and private schools, including those government decisions which affect the educational environment. The course focuses attention on a specific issue such as urban problems, comparative political systems, ideologies and American political institutions and processes. Designed primarily for secondary school teachers.

314. Workshop in Teaching Government (3)
Individual research projects on contemporary issues and discussion of proposals for curriculum revisions in the public and private schools. Outside speakers will be invited to attend workshop sessions. Must be taken concurrently with Govt 313 when courses are offered together.

317. The American Presidency (3)
Role of the executive in the American political process. Includes an analysis of the historical development, selection process, and scope of executive power. Olson

318. (IR 318) Communist Political Systems (3)
Examination of Communist political systems outside the USSR and the operations of nonruling Communist parties.

322. (IR 322) Politics of Developing Nations (3)
Theories of political development in non-Western areas; modernization and nation building. Field studies and methods; contributions of related disciplines such as sociology and psychology.

324. (IR 324) Political Systems in Transition (3) spring
The responses of selected non-Communist states to contemporary problems. May be repeated for credit with consnt of the department chairman. Yates

327. Socialization and the Political System (3)
The social, ideological and economic foundations of American politics. Emphasis on supporting institutions—family, schools, and workplace—and processes which foster political attitudes and behavioral patterns. Morgan

328. The Politics of Urban Policy (3)
The interplay of political forces in selected urban policy areas. Readings, lectures and a class simulation to concentrate on the roots of urban poverty; school desegregation, community control, fiscal reform; and the political role of community groups, government agencies, the courts, and social science. Morgan

331. Internship Seminar (3)
Integrated classroom and fieldwork approach to the study of local government; includes an internship in a local government or private agency. May be repeated for credit. Prerequisite: consent of the department chairman.

333. (SR 333) The Social Psychology of Politics (3)
Political behavior viewed from a psychological and social psychological perspective.

351. Constitutional Law (3) fall
The law of the Constitution as expounded by the Supreme Court of the United States. Nature and origins of judicial review, distribution and scope of governmental powers, and economic regulation in a federal system. Detailed consideration of judicial policy decision-making processes. Whitcomb

352. Civil Rights (3) spring
A study of constitutional development in political and civil rights. Freedom of speech and of the press, religious freedom, due process of law and equal protection of the laws. Detailed consideration of constitutional issues concerning criminal procedure and racial discrimination. Whitcomb

355. Public Personnel (3)
Problems in public personnel administration; the civil service and its reform; public employee unionism; due process within the organization; affirmative action; political neutrality of public servants. Barry

354. Administrative Law (3)
The authority, procedures, and methods used by executive agencies in the administration of public policy. Analysis of the

general problem of adjusting the administrative process to traditional constitutional principles. Barry

357. Technology Assessment (3)
Policy analysis of new and existing technologies in the United States; evaluation of societal consequences of technological decision-making and the identification of new alternatives in light of social needs.

359. The Legislative Process (3)
Organization and procedure of legislative and constituent assemblies. Legislative leadership. Role of administrative and judicial agencies in law-making. Pressure groups, parties, and policy determination. Direct legislation.

360. Public Administration (3)
The nature of administration; problem of organization and management; public personnel policies; budgeting and budgetary systems; forms of administrative responsibility. Colon

361. Field Research (3)
Application of basic research techniques to individual or small-group projects. Prerequisite: Govt 21 or consent of the chairman.

363. Contemporary Political Philosophy (3)
Continuation of Govt 102 with concentration on political philosophers after World War I.

364. Issues in Contemporary Political Philosophy (3)
Selected issues in contemporary political philosophy, such as political obligation and civil disobedience, participatory democracy and workers' control, "positivist" political analysis and the alleged decline of political philosophy. May be repeated for credit with the consent of the department chairman.

365. Political Values of Neo-Freudians and Existentialists (3)
The perspectives of Freud, Neo-Freudians such as Fromm and Marcuse, and existentialists such as Sartre and Camus. Yates

366. The Politics of Education (3)
The political dimensions of the contemporary crisis in American education.

368. Political Economy (3)
Significance to democratic theory of the concentration of economic power and its interface with the polity. McCoy

371. Readings (1-3)
Readings in political science assigned to properly qualified students in consideration of their special interest in particular political institutions and practices. Prerequisite: consent of the department chairman.

372. Readings (1-3)
Continuation of Govt 371. Prerequisite: consent of the department chairman.

381, 382. Special Topics (3)
A seminar on a topic of special interest in a particular political institution process, or policy. Prerequisite: consent of the department chairman.

For Graduate Students

The department of government offers a graduate program leading to the doctor of arts, the master of public administration, and the master of arts. The applicant for admission is required to demonstrate adequate undergraduate preparation, and may under certain circumstances be asked to submit Graduate Record Examination results.

Master of Arts

The master of arts in government is a thirty-credit-hour program which can be accomplished in twelve months by full-time students. A comprehensive examination is required. The student may take twenty-four hours of course work and six hours of thesis or may take all thirty credit hours in course work.

The master of arts program is intended for the student with liberal arts or natural science preparation who has a professional interest in government. The master of arts may be a preparatory step toward doctoral work at another institution or a final degree preparatory for teaching in junior and community colleges or research positions in governmental, institutional or industrial settings.

Master of Public Administration

The master of public administration is a final degree emphasizing career preparation for governmental service. The program is designed to emphasize administration in all levels of governmental service—national, state, urban and municipal—and non-governmental service in quasi-public and academic organizations.
The program consists of four parts:

1. **core curriculum** (twelve credit hours).
The core curriculum consists of courses in public administration, legal foundations of public administration, governmental budgeting and public policy.

2. **methodology and tools** (six credit hours).
Two methodology courses, one dealing with basic methodological issues and techniques and another with field applications and data analysis, are required. Govt 421 and Govt 460 are designed to fulfill these requirements, but other courses may be substituted with the approval of the adviser. Also, a basic proficiency in accounting is required.

3. **the general public administration/urban concentration option** (nine credit hours).
The student has the option of selecting a general program in public administration or one with an urban concentration. These electives, chosen in consultation with an adviser, may include courses from a number of departments such as government, economics, history, management, and social relations.

4. **internship** (three credit hours).
This will be a specially arranged program. If a student has broad practical experience in public service, the internship requirement may be waived at the discretion of the graduate committee. A thesis-level essay would then be substituted.

The final requirement for the master of public administration is a comprehensive examination.

Doctor of Arts

The doctor of arts program is designed for students holding the bachelor's or master's degree who wish to prepare for a career in college teaching of political science. The major emphasis of the program is on American politics and institutions. Course work is also available across a wide range of other aspects of political science, however. In every respect, the evaluation standards are equal to those of a doctor of philosophy program. Guidelines developed by the Council of Graduate Schools and American Association of State Colleges and Universities have been followed in planning this program.

The doctor of arts program differs from the doctor of philosophy program in five ways: the requirement of a broader distribution of graduate courses in government; a minor area of study for those students who wish to have bidisciplinary preparation for two-year college teaching; a general examination tailored to the doctor of arts; a nontraditional dissertation aimed at enhancing teaching competence; and supervised internships.

The student entering will follow one of three tracks, depending on whether he or she is: 1. beginning graduate work; 2. transferring up to thirty credit hours for a master of arts in political science; or 3. transferring up to thirty credit hours for a master of arts in a cognate field.

As currently structured, it is possible for the student entering with a bachelor of arts to complete the program in three years of full-time study. The full-time student entering with a master of arts, either in political science or in a cognate field, can complete it in two calendar years.

The doctor of arts program consists of four parts: a core concentration; a concentration in political science; a minor in a cognate field; and a dissertation.

the core curriculum (12 credit hours)
teaching government (3)
research methods (3)
teaching internship (3)
community internship (3)

In addition, it is recommended that doctor of arts students take Psych 411, Interpersonal Awareness.

political science concentration (24-51 credits)
The political science core requirements consist of twelve credit hours. Required courses are The American Polity and Theoretical Issues in American Politics. In addition, the student is required to take at least one graduate seminar from the public administration field (the courses include Public Administration, The Budgetary Process, The Legal Foundations of Public Administration and Public Policy Process) and at least one graduate seminar from the area of American government and public law (the courses include American Constitutional Development, Law and Social Policy, Urban Politics and Community Power Structure).

From twelve to thirty-nine additional credits in political science (coursework from other departments may be substituted if approved by the adviser) are required. The total number of credits will depend on the student's previous course work at the graduate level. The student's graduate coursework (including transfer credit) must include at least six credits in political theory and six credits in comparative politics.

The student is expected to register for 400-level courses where appropriate, but may fill out the course work with 300-level courses taken for graduate credit.

Cognate minor (nine credit hours). On the basis of interest and undergraduate education, students are encouraged to select their minor from a wide range of subject areas including both the natural and social sciences.

Students entering Lehigh with a master of arts in a cognate field may be excused from all course work in this area.

Dissertation (9-18 credit hours). The course credit allocated to the dissertation will vary from nine credit hours for the student who transfers with a master of arts in a cognate field, to eighteen credit hours for the student who enters the program with a bachelor of arts degree. Regardless of the credits allocated, the standards for the dissertation are identical.

Examination. Those students entering the doctor of arts program without the master's degree in political science will be required to take a continuing proficiency examination prior to their second year of study.

The general examination is taken prior to the commencement of the student's dissertation. It consists of a major written examination (six hours) on American politics and institutions and a minor written examination (three hours) covering the fields of comparative politics and political theory. An oral examination completes the general examination.

The student is required to defend the completed dissertation before the doctoral committee.

Graduate Courses

403. The American Polity (3)
Integrative overview of the American polity's emphasis on national institutions: presidency, Congress, judiciary, party systems and their interrelations.

405. The Budgetary Process (3)
The public budgetary process: competition among interest groups, policy outcomes, intergovernmental relations, and consequences for policy implementation.

407. American Constitutional Development (3)
The law of the Constitution as expounded by the Supreme Court of the United States. Nature and origins of judicial review, institutional aspects of separation of powers and federalism, economic regulation in a federal system, and political and civil rights. Detailed consideration of judicial policy-making processes and judicial biography. Whitcomb

411. The Legal Foundations of Public Administration (3)
The authority, procedures, and methods used by executive agencies in the administration of public policy and the general problem of adjusting the administrative process to traditional constitutional and legal principles. Barry

413. Modern Political Philosophy (3)
A study of selected modern political philosophers and their continuing effect on politics and political philosophy. Yates

414. Contemporary Political Philosophy (3)
Selected contemporary political philosophers and their responses to conditions of contemporary political life.

421. Research Methods (3)
Research approaches, design techniques, statistical and non-statistical analysis, and computer applications.

424. Administrative Theory (3)
Administrative theory and practice in both the public and nonpublic spheres in the United States; model building and field research emphasizing the concepts of public and private administrative systems. Colon

431. Public Administration (3)
The study of bureaucracy and the problems of public organization and management; executive leadership; personnel, budgeting and regulatory administration. Colon

432. Public Policy Process (3)
Impacts of power relationships on selected public policy areas such as the military, agriculture, housing, environment, energy, poverty, health, and taxation. May be repeated for credit. Olson

434. Field Work in Political Science Application (3)
Internship in private or public agency. May be repeated for credit.

437. Teaching Internship (3)
Supervised practice teaching at the college level. For doctor of arts students.

443. Law and Social Policy (3)
The role of law in the development of social policy. Emphasis on judicial and administrative rather than legislative processes. Substantive areas vary from semester to semester; some of the topics are: judicial administration, administrative regulation, law and social change, and foreign legal systems. May be repeated

451. Comparative Politics (3)
Theory and concepts in comparative politics. Analysis of applications in studies of Western and non-Western political systems.

460. Topics in Urban Politics and Policy (3)
Political power, race and poverty, public finance, redevelopment and environmental policy in urban areas. A class project. May be repeated for credit.

461. Community Power Structure (3)
A focus on power relations and decision-making on the community level. Special attention given to theories of community power.

471. Seminar in Teaching Government (3)
Theories and techniques of instruction, learning, evaluation, instructional design and innovation in the teaching of government. Prerequisite: doctor of arts candidacy or permission of the department chairman.

472. Workshop in Teaching Government (3)
Directed experience in teaching and instructional design of lower-division government courses.

481. Special Topics (3)
Individual inquiry into some problem of government. Reading, field work, and other appropriate techniques of investigation. Conferences and reports. May be repeated for credit.

482. Special Topics (3)
Continuation of Govt 481.

Hebrew

Modern Hebrew is taught in the department of modern foreign languages. Biblical Hebrew is associated with the department of religion studies. Consult these alphabetical listings in this section for course descriptions.

History

Professors. Lawrence H. Leder, Ph.D., *chairman*; Joseph A. Dowling, Ph.D., distinguished professor; John McV. Haight, Jr., Ph.D.; William G. Shade, Ph.D.; Charles L. Tipton, Ph.D.
Associate professors. Mark Ellis, Ph.D.; John H. Ellis, Ph.D.; James S. Saeger, Ph.D.; Roger D. Simon, Ph.D.
Assistant professors. Michael Baylor, Ph.D.; Ian P.H. Duffy, D. Phil.
Adjunct professor. Winfred Kohls, Ph.D.

History is the study of human activities. As such, it encompasses not only events and public policy, but the whole sweep of cultural achievements—religion and philosophy, literature and art, economic and social life. Some of the most influential thinkers and public people of our time (Toynbee, Kennan, Churchill, Kennedy, among others) have studied contemporary problems by viewing the forces in the past which have shaped our world.

Students take courses in three culture areas, examining major developments in each in terms of cause and effect, the historians' main concern. These courses provide training in research, analysis of historical problems, and formulation of historical judgments, as well as in writing. History majors have the foundation for law school, government service, journalism, teaching, and graduate study.

Honors study in history is by invitation of the department in the student's junior year. The student is required to attain an average of 3.25 in history courses, and must demonstrate a special competence in history. Those interested in honors work are urged to consult the department chairman early in their junior year.

Honors students in history may plan special programs, including more in-depth study of two culture areas rather than three. They enroll for three hours credit of unrostered history as part of their thirty-nine credit hours and complete in that course an honors thesis.

Distribution Requirements

The major totals thirty-nine credit hours.
A history major meets the following distribution requirements.
- Hist 1, 2
- maximum of twelve hours in courses below 100
- minimum of twelve hours in courses numbered above 200, not including Hist 201 and 395
- Hist 201 or 395
- maximum of eighteen hours of courses from any one group, and minimum of three hours from each group listed below.

Group A courses

Hist 7	Machine in America (3)
Hist 8	Medicine and Society in America (3)
Hist 9	Formation of American Society (3)
Hist 10	American Society in the Industrial Era (3)
Hist 53	Religion and the American Experience (3)
Hist 119	Colonial America (3)
Hist 120	Revolutionary America (3)
Hist 135	United States, 1789-1840 (3)
Hist 136	United States, 1840-1877 (3)
Hist 137	United States, 1877-1920 (3)
Hist 138	United States, 1920 to Present (3)
Hist 153	Religions and the American Experience (3)
Hist 322	American Economic History (3)
Hist 324	Women in America (3)
Hist 325	American Social History, 1607-1877 (3)
Hist 326	American Social History Since 1877 (3)
Hist 327	American Intellectual History (3)
Hist 328	American Intellectual History (3)
Hist 329	American Foreign Policy (3)
Hist 330	Modern American Foreign Policy (3)
Hist 331	The Negro in America (3)
Hist 332	Oral History (3)
Hist 333	American Urban History to 1880 (3)
Hist 334	American Urban History, 1880 to the Present (3)
Hist 338	Psychohistory (3)
Hist 339	Public Health in America (3)
Hist 340	History of American Medicine (3)
Hist 374	Themes in American History (3)
Hist 397	Administration of Historic Sites I (3)
Hist 398	Administration of Historic Sites II (3)

Group B courses

Hist 11	Survey of European History I (3)
Hist 12	Survey of European History II (3)
Hist 15	English History (3)
Hist 16	English History (3)
Hist 21	Ancient History (3)
Hist 22	Ancient History (3)
Hist 149	Barbarian West (3)
Hist 150	Medieval Civilization (3)
Hist 154	The Holocaust: History and Meaning (3)
Hist 157	The Renaissance and Reformation (3)
Hist 158	Age of Absolutism (3)
Hist 159	Modern Europe (3)
Hist 160	Modern Europe (3)
Hist 243	English History 1471-1660 (3)
Hist 244	English History, 1660-1789 (3)
Hist 257	France, 1715-1848 (3)
Hist 258	France, 1848 to Present (3)
Hist 261	A History of Russia to 1855 (3)
Hist 262	A History of Russia, 1855 to Present (3)
Hist 263	Modern Germany, 1618-1848 (3)
Hist 264	Modern Germany, 1848 to Present (3)
Hist 267	The Iberian Peninsula (3)
Hist 337	History of Medical Thought (3)
Hist 345	Liberal England (3)
Hist 346	Socialist England (3)
Hist 347	English Constitutional and Legal History to 1485 (3)
Hist 348	English Constitutional and Legal History Since 1485 (3)
Hist 351	Conservatism in the Modern Age (3)
Hist 355	European Intellectual History (3)
Hist 356	European Intellectual History (3)

Group C courses

Hist 4	Chinese Civilization (3)
Hist 49	History of Latin America (3)
Hist 50	History of Latin America (3)
Hist 265	Mexico and the Caribbean (3)
Hist 266	Argentina, Brazil and Chile (3)
Hist 368	Seminar in Latin American History (3)

Hist 20, 51, 52, 300, 371, 372, or provisional courses will be placed in one of the above groups in accordance with their contents and emphases.

History majors are encouraged to enroll in courses in economics, English and American literature, government, international relations, philosophy, psychology, religion studies, and social relations. Students intending to do graduate work should acquire a reading knowledge of at least one foreign language, choosing languages appropriate to their area of concentration.

Minor Programs in History

A student may establish a minor program in history which covers either a geographical, topical, or chronological interest (American, European, technological and medical, or 20th-century history, to mention a few possibilities). Each student's minor program is prepared in consultation with the chairman of the history department. The minor totals at least fifteen hours and conforms to the following pattern:

- six hours in courses numbered below 100
- maximum of six hours in 100 level courses
- minimum of three hours in courses numbered above 200

Museum Studies

Students considering postgraduate work toward a museum career are urged to enroll in History 397-398, Historic Sites Administration (3 credit hours each), and to elect the following museum-related courses in other departments: Art 175 and 275, Anthropology 131, SR 51 and 232.

Undergraduate Courses in History

The letters *UP* indicate that the course may be used to meet either preliminary or upperclass distribution requirements for students in the College of Arts and Science.

1. Course of Civilizations (3) P fall
Civilizations in the East, West and Africa from earliest times to 1700. Haight

2. Course of Civilizations (3) P spring
Civilizations in the East, West and Africa from 1700 to the present. Haight

4. Chinese Civilization (3) UP spring
Institutional, social and intellectual development of traditional China, and its transformation in the 19th- and 20th- centuries.

7. The Machine in America (3) P
American technology since colonial times. Changes in techniques and organization of processing, manufacturing, transportation and construction: consideration of social, cultural, and economic impact. Simon

8. Medicine and Society in America (3) P
Historical perspectives on values, ideas, and practices in American medicine. John Ellis

9. Formation of American Society (3) P fall
Social, economic, cultural and political institutions through Reconstruction, emphasizing their effects on public policy and culture.

10. American Society in the Industrial Era (3) P spring
Continuation of Hist 9, emphasizing the impact of industrialization on public policy, thought and social structure.

11. Survey of European History I (3) P
Major historic forces from the collapse of the Roman Empire to 1700; two lectures and one discussion per week.

12. Survey of European History II (3) P
Major developments from 1700 to the present; two lectures and one discussion per week.

15. English History (3) UP fall
The history of England to 1688. The origins of representative government, the development of English social institutions, the unification of England, and the Renaissance and Reformation in England. Duffy

16. English History (3) UP spring
English political and social institutions from 1688 to the present. The evolution of parliamentary government, the rise of modern parties, the industrial revolution, and recent social philosophies. Duffy

20. Workshop in History (1) P
Intensive examination of a particular problem or issue, offered only in conjunction with introductory courses. Student may either enroll in the introductory course or secure permission of the department chairman.

21. (Greek 21) Ancient History (3) P
The development of civilization from paleolithic times to the world empire of Alexander the Great. The social, economic, religious, philosophic, artistic, and literary development of the ancient world; the origin of political institutions. Phillips

22. (Latin 22) Ancient History (3) P
Continuation of Greek 21, The Hellenistic Age. Rome from its origin to 395 A.D. Phillips

49. History of Latin America (3) UP fall
Spanish and Portuguese colonization of America and the struggles for independence, preceded by a brief view of the ancient American civilizations and the Iberian backgrounds. Saeger

50. History of Latin America (3) UP spring
Continuation of Hist 49. The development of the Latin American nations in the 19th and 20th centuries. Saeger

51. Freshman Seminar (3) P
An intensive analysis of a particular period, problem or area of history, emphasizing readings, discussions and reports. The topics and instructor vary each semester. Open by invitation to students with advanced placement credit in history or equivalent background, or upon application to the chairman of the department.

52. Freshman Seminar (3) P
A continuation of Hist 51.

53. (RS 53) Religion and the American Experience (3) fall
The historical development of major religious groups in this country from colonial times to the present. Their place in social and political life, and the impact of the national experience upon them. Emphasis on religious freedom and pluralism, and the church-state relationship. Alice Eckardt

119. Colonial America (3) fall
Founding and growth of colonies in North America through circa 1750. Attention will be paid to motives behind European expansion as well as to developments in the colonies. Leder

120. Revolutionary America (3) spring
American political, economic and cultural development from the mid-18th century through the adoption of the Federal Constitution. Leder

135. United States, 1789-1840 (3)
The American political system from the Constitution through Jacksonianism. Special emphasis upon the first and second party systems and the democratization of American political culture. Shade

136. United States, 1840-1877 (3)
Civil War and Reconstruction, emphasizing the causes of the Civil War, its impact upon American society and politics, and problems of postwar reconstruction. Shade

137. United States, 1877-1920 (3)
Political, economic and social responses to industrial America. The rise of the Populist and Progressive movements, coming of World War I, and postwar developments. J.H. Ellis

138. United States, 1920 to Present (3)
American institutions in the modern era, emphasizing critical changes of the 1920s, the Crash of 1929, the New Deal, World War II, and later political, social and economic events. Dowling

149. The Barbarian West (3) fall
Merger of Greco-Roman, Germanic and Christian institutions and culture in Western Europe to mid-11th century. Evolution of the church, feudalism and manorialism, and the foundations of the Carolingian and Holy Roman empires. Tipton

150. Medieval Civilization (3) spring
Formation and development of western culture to about 1400. Rise of universities and towns, legal development and origins of representative government, origins of nation-states, scholasticism and decline of the medieval church. Tipton

154. (RS 154) The Holocaust: History and Meaning (3) spring
The Nazi Holocaust in its historical, political and religious setting. Emphasis upon the moral, cultural and theological issues raised by the Holocaust. Alice Eckardt

157. (RS 157) The Renaissance and Reformation (3) fall
The transition from medieval to modern society. Consideration of political, economic and social forces produced by the Renaissance and their influence upon the dominant religious theme of the Reformation era. Baylor

158. Age of Absolutism (3) spring
Seventeenth- and eighteenth-century Europe: emergence of absolutist monarchies and the European state system; social foundations of politics; the Enlightenment; the relation of cultural and political life. Baylor

159. Modern Europe (3) fall
Revolutions and reactions in Western Europe from 1789 to 1870. The rise and spread of liberalism and the origins of socialism. Haight

160. Modern Europe (3) spring
Contemporary Europe; the origins and consequences of two world wars; the rise of revolutionary governments in Italy, Germany and Russia. Haight

For Advanced Undergraduates and Graduate Students

201. Historical Perspectives (3) spring
Methodologies and interpretations of Western historians from ancient times to the present. Tipton

243. English History, 1471-1660 (3) fall
England under the Tudor monarchy and the problems facing its successors culminating in the civil wars and Interregnum. Political, economic, intellectual and religious developments of the period. G.M. Ellis

244. English History, 1660-1789 (3) spring
Constitutional monarchy from the Stuart Restoration to the French Revolution. English civilization in an age of oligarchy, especially the political, social, economic and intellectual sectors. G.M. Ellis

257. (French 257) France, 1715-1848 (3)
Interrelation of politics, economics, social forces, and culture from Louis XV through the Revolution of 1848. Haight

258. (French 258) France, 1848 to Present (3)
Interrelation of politics, economics, social forces, and culture from the Revolution of 1848. Haight

261. A History of Russia to 1855 (3) fall
Major cultural, social, and political traditions of the Russian people. Kohls

262. A History of Russia, 1855 to Present (3) spring
The Great Reforms, collapse of Tsarist absolutism, revolution of 1917, and formation and consolidation of the Soviet dictatorship. Kohls

263. Modern Germany, 1618-1848 (3) fall
Political, socio-economic, and cultural developments from the age of triumphant absolutism to the failure of liberalism. Baylor

264. Modern Germany, 1848 to Present (3) spring
Political history from the Second Empire to the federal and socialist republics. Twentieth-century intellectual and social problems. Baylor

265. Mexico and the Caribbean (3)
Emphasis on Mexico and Cuba from the era of Bourbon reforms through the wars of independence to the 20th-century revolutions. Saeger

266. Argentina, Brazil and Chile (3)
Eighteenth-century Spanish imperial readjustments, independence, the emergence of new societies, 20th-century extremist movements, and the problems of developing nations. Prerequisite: consent of the department chairman. Saeger

267. The Iberian Peninsula (3)
Rise and fall of Spain and Portugal as European and colonial great powers in the early modern period; their development after the Industrial Revolution; emphasis on Spanish Civil War (1936-39). Saeger

300. Apprentice Teaching (3)
See the introduction to this section for an explanation.

322. American Economic History (3)
Economic development since the colonial period, emphasizing the rapid industrialization from 1820 to 1890 and the social impact of economic change. Simon

324. Women in America (3)
Roles of women in American society from colonial to present times: attitudes toward women, female sexuality, women's work, and feminism. Shade

325. (SR 325) American Social History, 1607-1877 (3) fall
Social change from early agrarian communities to beginnings of industrialism, emphasizing socio-economic class, family structure, and treatment of women and minority groups. Shade

326. (SR 326) American Social History Since 1877 (3) spring
Changing role of women, minorities, and the family during the industrial era. Development of the modern class structure and the impact of the welfare state. Simon

327. American Intellectual History (3) fall
Development of political, social and religious ideas in America from the colonial period to the Civil War. Dowling

328. American Intellectual History (3) spring
Economic, political and religious thought in industrial America, 1860 to the present. Dowling

329. American Foreign Policy (3)
Late 18th-century origins of American diplomatic ideas, their development and application through the 19th century. Leder

330. Modern American Foreign Policy (3)
The United States in world affairs from the late 19th century to the present; the testing and revision of traditional ideas in the face of changing needs and responsibilities. Saeger

331. The Negro in America (3)
Negro subculture in America from the colonial period to the present, emphasizing the struggle for emancipation and equal rights. Topics include: racialism, slavery, Reconstruction, urbanization, protest movements, and the "Second Reconstruction." J.H. Ellis

332. Oral History (3)
Capturing historical data through recorded interviews with individuals who have lived through or participated in significant events. Emphasis on students' techniques in conducting interviews. Themes vary. Equipment and materials loaned by the department. Simon

333. American Urban History to 1880 (3) fall
Planning and design of colonial and frontier cities. Impact of transportation innovations and industrialization, emergence of a national system of cities. Internal problems of early industrial cities: housing, transportation, public health, crime, social mobility. Simon

334. American Urban History, 1880 to Present (3) spring
Physical expansion of the industrial city and its relationship to current urban problems. Suburbanization, development of the

central business district, reforms in housing and public health, rise of ghettoes, emergence of the city planning profession and the idea of "new towns," impact of the New Deal and "urban renewal." Simon

337. History of Medical Thought (3)
From prehistory to present: shamanism and healing, Greco-Roman medicine, Paracelsus and Harvey, and the germ theory of disease. J.H. Ellis

338. Psychohistory (3) spring
Uses of psychology in history and biography; exploration of problems of methodology, verification of evidence, conceptual frameworks and theories of personality; potentialities and limitations of psychological investigation as an historical technique. Dowling

339. Public Health in America (3)
Economic, political and social influences on the development of public health. The changing concept of disease, sanitation, and control of nature and man; idea of "state medicine." J.H. Ellis

340. History of American Medicine (3)
Institutional development of the American medical profession. J.H. Ellis

347. English Constitutional and Legal History to 1485 (3) fall
Origins and development of government, administration, and law from Anglo-Saxon times to 1485, emphasizing common-law institutions, practices and procedures. Tipton

348. English Constitutional and Legal History Since 1485 (3) spring
Emphasis on development and problems of sovereignty, constitutional monarchy, the cabinet system, and legal and administrative changes in the modern era. Duffy

349. Topics in Modern British History (3)
Selected topics since 1789, including the class system, the transition from aristocracy to democracy, the welfare state, imperialism, the Irish question, modern political parties, and loss of great-power status. Duffy

350. English Economic History Since 1700 (3)
Emphasizes the industrial revolution, mid-Victorian prosperity, the Great Depression, and the impact of two world wars. Duffy

351. Conservatism in the Modern Age (3)
Conservative political, economic, and social thought from the 18th century to the present. Tipton

355. (RS 355) European Intellectual History (3) fall
Political and religious thought and other aspects of the history of ideas in Europe from the Middle Ages to about 1700. Baylor

356. European Intellectual History (3) spring
A continuation of Hist 355, with special attention given to the impact of the industrial revolution upon the development of 19th and 20th-century ideologies. Baylor

368. Seminar in Latin American History (3)
Readings and individual investigation of selected topics. Saeger

371. Special Topics in History (1-3)
Intensive study in an area of history not adequately covered in currently listed offerings. The course may be administered as a reading program or otherwise as may seem best to meet the needs of students of unusual ability and adequate preparation. Prerequisite: consent of the department chairman.

372. Special Topics in History (1-3)
Continuation of Hist 371. Prerequisite: consent of the department chairman.

374. Themes in American History (3)
An intensive study of a selected topic in American history primarily for American Studies majors. The topic may vary from time to time as the needs of the American Studies program dictate. The seminar allows study of an aspect of American history in greater depth than is generally the case. Prerequisite: permission of the director of American Studies. Dowling

395. Quantitative Methods in Historical Studies (3) spring
Historical uses and methods of quantitative analysis, including the application of descriptive statistics, statistical inference, and computer technology to a variety of problems drawn from European, American and Latin American history. Shade

For Graduate Students in History

Linderman Library is especially rich in materials for advanced study and research in history, and the department of history offers program leading to master of arts and doctor of philosophy degrees. Graduate programs provide intensive and specialized study, and the policy of limited enrollment permits close relations between faculty and students.

Admission to graduate study in history is competitive and dependent upon the applicant's undergraduate preparation and record, recommendations, and Graduate Record Examination scores. Besides general requirements for the Graduate School, the following special requirements apply to graduate study in history.

Master of Arts

There are two masters programs. Under plan I, a candidate may earn the degree by successfully completing twenty-four hours of approved course work and submitting a satisfactory thesis. Those continuing toward a doctorate elect Plan I. Candidates declaring Plan II do not write a thesis, but take thirty hours of course work in and pass examinations in two fields chosen from American, British, European and Latin American history. Master's candidates are required to maintain a 3.0 average in all graduate work.

Doctor of Philosophy

Candidates for the doctor of philosophy in history must maintain a 3.25 history average and a 3.0 over-all average on all graduate work taken at Lehigh or elsewhere.

Students entering with a master's degree take a qualifying examination before beginning their second semester at Lehigh. During the second semester, doctoral students select four history fields and one outside field and prepare themselves for written and oral examinations in those fields. Course work is required in a fifth history field, but it will not be covered in the comprehensive examinations. An original dissertation is required and may be written only in a primary field.

Primary fields. Primary fields are Great Britain, Colonial America, 19th-Century America, and 20th-Century America.

Other fields. Other fields of specialization are Medieval-Renaissance, Modern Europe to 1789, Modern Europe Since 1789, and Latin America.

Language requirements. The qualifying examination in one language must be passed before beginning course work beyond the master's degree in order that the language may be used in doctoral course work. The candidate's special committee, appointed by the chairman of the department, will designate any additional languages for the student, if needed. Languages normally chosen are French, Spanish, Italian, German or Russian.

All graduate majors take Hist 401 and either 404 or 405.

More detailed regulations are given in the *Handbook for Graduate Work in History*, available in the history department office.

401. Methods in Historical Research (3) fall
Techniques of research in history: training in the critical handling ol documentary materials, in measuring the value of evidence, and in formal presentation of the results of research. Required of all graduate students in history. Tipton

404. Historiography: Europe (3)
The approach, methods and interpretations of the leading historians of Europe.

405. Historiography: America (3)
The approach, methods and interpretations of the leading historians of America.

442. Readings in American History (3)
Study in small groups under the guidance of a faculty member of the literature of a particular period, problem, or aspect of American history. May be repeated for credit with permission of the department chairman.

443. Readings in English History (3)
Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem, or area of English history. May be repeated for credit with permission of the department chairman.

444. Readings in Latin American History (3)
Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem, or area of Latin American history. May be repeated for credit with permission of the department chairman.

447. Readings in European History (3)
Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem, or aspect of European history. May be repeated for credit with permission of the department chairman.

452. Research in American History (3)
An intensive research seminar on a phase of American history. May be repeated for credit with permission of the department chairman.

453. Research in English History (3)
An intensive research seminar on a phase of English history. May be repeated for credit with permission of the department chairman.

454. Research in Latin American History (3)
An intensive research seminar on a phase of Latin American hsitory. May be repeated for credit with permission of the department chairman.

457. Research in European History (3)
An intensive research seminar on a phase of European history. May be repeated for credit with permission of the department chairman.

Human Development

This department is one of three such organizations operating within the School of Education. Therefore, consult the School of Education entry in this section for a description of the program and course descriptions in Human Development (page 123).

Humanities Perspectives on Technology

Steven L. Goldman, *director* and professor of philosophy

The Humanities Perspectives on Technology (HPT) program is the product of a continuing intercollege effort to create a common ground from which to explore the relations between science, technology and society: between ideas, machines and values.

The HPT program promotes the development of undergraduate courses that analyze the social and personal implications of science and technology and that study the natures of both from the perspective of the human subjects engaged in these activities. Its most basic commitment is to the view that science and engineering are cultural phenomena and hence essentially human enterprises.

HPT serves as a focal point for a wide range of courses—from music and art to philosophy to physics and metallurgy—in many departments that treat one or another facet of these themes, lending coherence and visibility to offerings otherwise dispersed throughout the catalog. The program also offers a minor in Technology and Human Values, open to all undergraduates, for which students take a set of courses drawn together by their common HPT focus and consisting of at least eighteen credit hours of work, with two required courses and four electives. The student takes HPT 11 or HPT 113 and a course in the history of technology, such as Hist 7 or Clss 206. The elective courses, spread over the various fields in the humanities and social sciences, are chosen with the advice of the director of the program in consultation with the student.

Humanities Perspectives on Technology Courses

11. Technology and Human Values (3) fall
Impact of technology on society in relation to ethical problems raised by the exploitation of technological innovations. Illustrations from literature, art, philosophy, history, folklore and film.

113. Science and Human Values (3) spring
Investigation of the relationship between theories of Nature and theories of Man. Classical, modern, and contemporary scientific interpretations of Nature examined for the interpretations of Man embedded in them.

181. Independent Study (1-3) fall-spring
Prerequisite: consent of the program director.

Other HPT Courses. The following special courses are offered by various departments. Descriptions may be found under the entry for the individual department.

Biol 1	Biology and Society
Clss 204	The Ancient City
Clss 206	Ancient Technology
Eco 311	Environmental Economics
Engl 81	American Literature and Science
Engl 89	Science Fiction
Engl/Phil 150	Media and Values
Engl 197	Myth of Knowledge
Engl 198	Utopia: Fantasy or Reality
Engl 383	Experimental Literature
F.A. 16	Media and the 20th Century Vision
F.A. 209	Architecture, 1750-1880
F.A. 210	20th Century Architecture
Gov 357	Technology Assessment
Hist 7	The Machine in America
Hist 8	Medicine and Society
Hist 337	History of Medical Thought
Hist 339	Public Health in America
Hist 340	History of American Medicine
HPT/Journ 124	Politics of Science
HPT/Met 221	Materials and the Development of Man
IR 41	Science, Technology, and International Relations
IR 80	Politics of Oil
IS 11 or IS 12	Computer Programming—Applications for the Humanities and Social Sciences
IS 202	Computers and Society
Journ 123	Basic Science Writing
Journ 125	Environment, Public and Mass Media
Journ 126	Writing about the Environment
Journ 312 or Journ 313	Advanced Science Writing or Special Topics in Science Writing
Mus 153	Electronic Music
Phil 42	The Scientific Process

Phil/Psych 75	Behavior Control and Human Values
Phil 100	Philosophy of Contemporary Civilization
Phil 116	Medical Ethics
Phil 161	Science, Philosophy, and Religion
Phil 261	Introduction to the Philosophy of Science
Psych 201	Industrial Psychology
RS 133	Science, Theology, and Technology
SR 5	The Social System
SR 131	Science, Technology, and Society
SR 151	Utopia and Alternative Communities
SR 311	Social Ecology

The program is constantly developing new courses. Bulletins announcing and describing them are published regularly. For further information, consult the director.

Industrial Engineering

Professors. George E. Kane, M.S., *chairman*; Arthur F. Gould, M.S.; Mikell P. Groover, Ph.D.; Sutton Monro, B.S.; Wallace J. Richardson, M.S.
Associate professors. John W. Adams, Ph.D.; Ben L. Wechsler, Ph.D.; Emory W. Zimmers, Jr., Ph.D.
Assistant professors. Larry E. Long, Ph.D.; Louis J. Plebani, Ph.D.; George R. Wilson, Ph.D.
Instructor. Andrew N. Kreutzer, M.S.

The curriculum is designed with the principal aim of industrial engineering in view, which is the design, improvement, and installation of integrated systems of people, materials, and equipment for operations by the application of the principles of the mathematical, physical, and behavioral sciences.

Throughout the program there is an integrated series or sequence in the major field which includes not only basic and fundamental courses but specialized courses as well, in the fields of production planning and control, quality control, computer-aided manufacturing, production engineering, information systems, and operations research. These specialized courses reflect the impact of recent developments in operations research, information processing, and automation.

Career Opportunities

There is a growing tendency on the part of industries to select young people from their engineering departments for managerial positions. Because of this the industrial engineering courses are oriented to the principles of scientific management to enable the industrial engineering graduate to accept and succeed in these opportunities.

It is the aim of the industrial engineering program to develop the potential manager for either the manufacturing or service industries as well as the government agency, a graduate well grounded in the fundamentals of science, trained in the principles of engineering analysis and design, and thus adequately prepared to practice the profession of industrial engineering.

Physical Facilities

The manufacturing processes laboratory affords an opportunity to students for gaining understanding and skills in manufacturing processes, experimental design, collection of data, and instrumentation calibration. The computer-aided manufacturing laboratory presents the student with an opportunity to use a minicomputer and micro-processors for both data collection and process control. The information systems laboratory serves the student by presenting opportunities in interactive programming, data processing, and data base systems.

Considerable use is made of the Computing Center facilities in all levels of course work.

Special Programs

Electives within the industrial engineering curriculum. The industrial engineering curriculum offers an extensive program of electives that permits the student to shape a program of study that reflects personal interests. The over-all program of electives is comprised of:
21 credit hours of engineering science electives
15 credit hours of advanced industrial engineering electives
15 credit hours of General Studies electives.
9 credit hours of free electives

Use of electives to emphasize an area within industrial engineering. Lehigh's industrial engineering department emphasizes four areas: information systems, manufacturing engineering, operations research and operations management. Students may choose their electives to emphasize one of these areas. Examples of using the elective program for this purpose are as follows:

Information Systems Emphasis

suggested course work

engineering science (21 credit hours)

EE 20, 105, 141	Circuits and Circuit Theory
Mech 103	Principles of Mechanics
CE 121	Mechanics of Fluids
Met 63	Materials Science
Mech 103	Principles of Mechanics

IE electives (15 credit hours)

IE 307	Information Systems Analysis
IE 309	Information Systems Development
IE 310	File Structure and Processing
IE 311	Decision Processes
IE 342	Computer-Aided Manufacturing

General Studies (15 credit hours)

Phil 14	Foundations of Logic
Journ 21	Creative Writing
Journ 311	Science Writing
SR 131	Science, Technology and Society
Psych 1	Introduction to Psychology

free electives (9 credit hours)

Math 105	Computer Programming and Computer Languages
Mgt 270	Organizational Theory *or*
IE 334	Organizational Planning and Control
IE 325	Production Control *or*
Acct 311	Accounting Information Systems

Manufacturing Engineering Emphasis

suggested course work

engineering science (21 credit hours)

Mech 1, 11, 102	Mechanics of Solids
Met 63, 315	Materials Science
CE 121	Mechanics of Fluids
EE 160	Electrical Science *or*
ME 104	Thermodynamics

IE electives (15 credit hours)

IE 325	Production Control
IE 335	Sampling and Quality Control
IE 340	Production Engineering
IE 342	Computer-Aided Manufacturing
IE 344	Metal Cutting Theory

General Studies (15 credit hours)

SR 131	Science, Technology and Society
Psych 1	Introduction to Psychology
Eco 105	Microeconomic Analysis
Eco 335	Labor Economics
Hist 7	The Machine in America

free electives (9 credit hours)

Engl 142	Technical Writing
IE 311	Decision Processes *or*
IE 334	Organizational Planning and Control
IE 336	Analysis of Experimental Data

Operations Research Emphasis

suggested course work

engineering science (21 credit hours)

EE 160, 317, 342	Electrical Science
CE 121	Mechanics of Fluids
Mech 1, 102	Mechanics of Solids
ME 104	Thermodynamics

IE electives (15 credit hours)

IE 311	Decision Processes
IE 315	Advanced Operations Research Techniques
IE 325	Production Control
IE 335	Sampling and Quality Control
IE 336	Analysis of Experimental Data

General Studies (15 credit hours)

Phil 14	Foundations of Logic
Phil 314	Logical Theory
SR 131	Science, Technology and Society
Hist 7	The Machine in America
Eco 105	Microeconomic Analysis

free electives (9 credit hours)

Math 309	Probability Theory
IE 307	Information Systems Analysis
IE 309	Information Systems Development

Operations Management Emphasis

suggested course work

engineering science (21 credit hours)

Mech 1, 11, 102	Mechanics of Solids
Met 63, 315	Materials Science
EE 160	Electrical Science
CE 121	Mechanics of Fluids *or*
ME 104	Thermodynamics

IE electives (15 credit hours)

IE 309	Information Systems Development
IE 311	Decision Processes
IE 325	Production Control
IE 342	Computer-Aided Manufacturing
IE 334	Organizational Planning and Control *or*
IE 335	Sampling and Quality Control

General Studies (15 credit hours)

Eco 105	Microeconomic Analysis
Eco 229	Money and Banking
Eco 335	Labor Economics
Hist 7	The Machine in America
Psych 1	Introduction to Psychology

free electives (9 credit hours)

Law 201	Business Law *or*
Fin 225	Business Finance
Mkt 211	Contemporary Marketing
IE 340	Production Engineering or
IE 310	File Structure and Processing

Options Through Electives

The following section shows how use of electives can help students achieve educational goals.

To pursue a technical minor. Students may elect to use their electives to obtain a technical minor. A technical minor requires a minimum of fifteen credit hours.

The engineering minors available to industrial engineering majors include molecular biophysics, chemical processing and computer engineering. The computer engineering minor could be accomplished in the following manner:

EE 11	Principles of Computing Techniques (free elective
EE 141	Switching Theory and Logic Design (engineering science elective)
EE 315	Principles of Computer Software (free elective)
EE 311	Compiler Design (free elective)
EE 317	Analytical Methods for Information Sciences (engineering science elective)

To pursue a nontechnical minor. Students may choose to pursue nontechnical minors ranging from classics to economics. A nontechnical minor requires a minimum of fifteen credit hours. A possible minor in economics might be accomplished as follows:

Eco 219	Macroeconomic Analysis (General Studies elective)
Eco 303	Economic Development (General Studies elective)
Eco 310	Economic Evolution (General Studies elective)
Eco 311	Environmental Economics (General Studies elective)
Eco 335	Labor Economics (free elective)

To fulfill background requirements leading to the master of business administration. The College of Business and Economics offers a master of business administration degree program. The program as presented would take two years, the first year being a set of prerequisites. Based on an agreement with the College of Business and Economics, it is possible to realize all first-year prerequisites to the master of business adminstration as part of the bachelor of science in industrial engineering program. Thus, it is possible to obtain the master of business administration in one year after completing the bachelor of science in industrial engineering given that requirements for admission to the Graduate School are met.

The bachelor of science in industrial engineering would meet the master of business administration requirements as follows:

Acctg 51, Essentials of Accounting, is required.

IE 18, Data Processing Fundamentals, is substituted for Acctg 111, Computers in Business.

IE 205, Engineering Statistics, is substituted for Eco 45, Statistical Method.

IE 206, Operations Research Techniques, is substituted for Mgt 269, Management of Operations in Organizations.

Fin 225, Business Finance, is taken as a free elective.

Mkt 211, Contemporary Marketing, is taken as a free elective.

Law 201, Business Law is taken as a free elective.

Eco 229, Money and Banking, is taken as a General Studies elective.

Eco 105, Microeconomic Analysis, is taken as a General Studies elective.

IE 334, Organization Planning and Control, is substituted for Mgt 270, Conceptual Foundations of Organizational Theory and Behavior.

To emphasize another engineering discipline. By careful use of the electives, a student can select many of the basic courses in another branch of engineering. This type of preparation would benefit the student interested in an operations management career in an industry emphasizing a particular branch of engineering.

Courses that might be selected by a student interested in emphasizing mechanical engineering are the following:

engineering science electives

Mech 1	Statics
ME 104	Thermodyanics I
Mech 11	Mechanics of Materials
Met 63	Engineering Materials
Mech 102	Dynamics
ME 231	Fluid Mechanics

free electives

ME 101-102	Mechanical Engineering Design
ME 312	Synthesis of Mechanisms *or*
ME 321	Introduction to Heat Transfer
ME 340	Advanced Mechanical Engineering Design

Major Requirements

freshman year (see page 43)

sophomore year, first semester (16 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
IE 7	Deterministic Models (4)
Phys 21, 22	Introductory Physics II and Laboratory (5)
	engineering science elective (3)

sophomore year, second semester (16 credit hours)

IE 110	Engineering Probability (3)
IE 18	Data Processing Fundamentals (3)
	engineering science electives (6)
Eco 1	Economics (4)

junior year, first semester (16-19 credit hours)

IE 101	Fundamentals of Manufacturing Engineering (4)
IE 205	Engineering Statistics (3)
Math 205	Linear Methods (3)
	engineering science elective (3)
	General Studies elective (3)
	elective (0-3)*

junior year, second semester (17 credit hours)

IE 104	Work Systems (4)
IE 206	Operations Research Techniques (4)
	engineering science electives (6)
	General Studies elective (3)

summer

IE 100	Industrial Employment

senior year, first semester (15-18 credits)

Acctg 108	Fundamentals of Accounting (3)
IE	Electives (6)
	engineering science elective (3)
	General Studies elective (3)
	elective (0-3)*

senior year, second semester (15-18 credits)

IE 154	Senior Project (3)
IE	electives (9)
	General Studies elective (3)
	elective (0-3)*

For engineering science electives, see the approved list in the industrial engineering office.
*please refer to description of normal program, page 43.

Undergraduate Courses

7. Deterministic Models (4) fall
The study of deterministic models related to production and inventory control as well as basic engineering economy. Laboratory.

18. Data Processing Fundamentals (3) spring
Study of data representation and recording media. The functions of computer input/output devices, storage devices, and the central processing unit. Fundamentals of system analysis and design of computer based information systems. Interactive and batch programming projects using Fortran IV and introductory Cobol. Laboratory. Prerequisite: Engr 1 or equivalent.

100. Industrial Employment (0)
Usually following the junior year, students in the industrial engineering curriculum are required to do a minimum of eight weeks of practical work, preferably in the field they plan to follow after graduation. A report is required. Prerequisite: sophomore standing.

101. Fundamentals of Manufacturing Engineering (4) fall
Study of metal processing theory and applications with emphasis on machining and pressworking, automation and numerical control, special processing techniques, workholder design principles. Laboratory.

104. Work Systems (4) spring
Techniques in methods improvement and work measurement. The applications of these techniques to the analysis, design and control of man-machine work systems. Time study, predetermined time systems, work sampling and standard data. Wage incentive plans and manufacturing control applications. Plant layout project. Laboratory. Prerequisites: IE 101, IE 205.

105. Thesis (3-6)
Candidates for the bachelor degree in industrial engineering may, with the approval of the department faculty, undertake a thesis as a portion of the work in the senior year. Prerequisite: senior standing.

110. Engineering Probability (3) spring
Introduction to the ideas and concepts of elementary probability theory. Intended to provide the background for courses involving statistical analysis of engineering data. Laboratory. Prerequisite: Math 23 previously or concurrently.

154. Senior Project (3) fall-spring
Special study in a problem involving project work in a local industrial plant or service institution. Project work includes consideration of the behavioral sciences. Laboratory. Prerequisite: senior standing in industrial engineering.

168. Production Analysis (3) fall-spring
A course for the engineering student not majoring in industrial engineering. Engineering economy; application of quantitative methods to facilities analysis and planning, operations planning and control, work measurement and scheduling, and operating systems analysis. Prerequisites: Math 22 or 42; Eco 1.

For Advanced Undergraduates and Graduate Students

205. Engineering Statistics (3) fall
Applications of point and confidence interval estimation and hypothesis testing to the fitting of frequency and regression models, to acceptance and control sampling and to elementary design of experiments. Simulation in practice to evaluate unfamiliar statistics. Exposure to a major statistical software package. Prerequisite: IE 110 or Math 231, or equivalent.

206. Operations Research Techniques (4) spring
The development and use of elementary techniques of operations research. Topics include linear programming, queueing theory, probabilistic inventory models, simulation and decision analysis. Prerequisite: IE 110 or Math 231.

212. Elementary Design of Experiments (3)
An introduction to the structure of experiments, the analysis of experimental data, and their interrelation. Measurement error, randomization, pairs and blocks, regression, and analysis of variance. Prerequisite: graduate standing or consent of the department chairman.

300. Apprentice Teaching in IE (1-3)
See the introduction to this section for an explanation.

307. Information Systems Analysis (3) spring
Study of techniques used, and their application, in the design of information systems. Graphical, matrix, and investigative techniques used in system definition; information network models; simplification methods, feedback concepts; simulation. Prerequisite: IE 18 or Acctg 111, IE 206 or Mgt 302, or equivalent.

309. Information Systems Development (3) fall
Study of information systems development to include design, implementation, evaluation and management. Introduction to data structure concepts, their use in the production of information for an organization and their effects on organizational relationships. Conduct a feasibility study for an information system. Prerequisite: IE 18 or Acctg 111 or equivalent.

310. File Structure and Processing (3) spring
Study of data structures and file organization for effective processing by computer to include storage management and generation, update, sorting, searching, and query techniques

using Cobol. Introduction to data base design and data base management systems. Prerequisite: IE 309 or Acctg 311, or equivalent.

311. Decision Processes (3) spring
Application of the techniques of operations research for decision making. Topics include decisions under certainty, decisions under risk, decisions under uncertainty, value of sampling information, decision trees and game theory. Prerequisite: IE 206 or Mgt 302.

315. Advanced Operations Research Techniques (3) fall
A survey of advanced topics in operations research. Topics include advanced linear programming, dynamic programming, integer programming, Markov chains and network techniques. Prerequisite: IE 206 or consent of department chairman.

321. Experimental Industrial Engineering (1-3)
Experimental projects in selected fields of industrial engineering, approved by the instructor. A written report is required.

322. Experimental Industrial Engineering (1-3)
Continuation of IE 321.

325. Production Control (3) fall
Quantitative techniques appropriate for the analysis of production and inventory control systems. Topics include forecasting, inventory models, aggregate planning, scheduling and sequencing. Prerequisite: IE 206 or Mgt 302, or equivalent.

334. Organizational Planning and Control (3) fall
Design of organization and procedures for managing functions of industrial engineering. Analysis and design of resources planning and control, including introduction of change in man-machine systems; manpower management and wage administration. Prerequisite: IE 104 or 168.

335. Sampling and Quality Control (3) fall
Random, stratified and optimal sampling plans, using fixed and sequentially determined sample sizes. Application to quality assurance and other analyses of operations. Stochastic methods for continuous inspection and Bayesian procedures for acceptance inspection. Prerequisite: IE 205.

336. Analysis of Experimental Data (3) spring
Use of linear and nonlinear least squares to find models which identify cause and estimate effect. Application of transformation, analysis of variance and covariance. Prerequisite: IE 205.

340. Production Engineering (3)
Develop plans of manufacturing for discrete parts. Product design analysis and engineering materials utilization. Economic analysis of process design alternatives. Introduction to mechanization and automation. Term project. Laboratory. Prerequisite: IE 101.

342. Computer-Aided Manufacturing (3)
Analysis and design of manufacturing systems using digital computers. Principal topics: computer-aided design techniques, group technology, applications of mini-computers to manufacturing systems. Introduction to adaptive control, numerical control, and optimization strategies for discrete parts manufacturing. Term project. Prerequisites: IE 18, IE 101 or equivalent.

344. Metal Cutting Theory (3) spring
Intensive study of metal cutting emphasizing temperature and energy relationships and their effect on tool life, power requirements and surface finish. Economic balancing of metal cutting variables from application of theory. Lectures and laboratory experiments including designing and conducting an original experiment. Prerequisite: IE 101.

Graduate Programs

Programs leading to the master of science and doctor of philosophy degrees are offered by the department in the following fields: manufacturing engineering, information systems, and operations research.
These programs, briefly described, are as follows:

Master of science in industrial engineering. The minimum program for the master of science degree consists of twenty-four credit hours of approved course work and completion of a satisfactory thesis.

A master of science program is selected to meet the interests and needs of the student, and courses in other departments for which the student has the prerequisites may be integrated into the major field. Subject to proper approval, nine credit hours of 400-level courses from outside the department may be included among the courses required in the major field. As part of a purposeful major program, collateral courses may be taken in other branches of engineering, mathematics, economics, psychology, and information and computer science.

Master of science in management science. The department and the College of Business and Economics administer an interdisciplinary program leading to a master of science degree in management science. Students are admitted and enroll in either department for administrative purposes. The minimum program consists of thirty credit hours of approved coursework.

Master of science in computer science. The department, in conjunction with the departments of electrical engineering, mathematics, philosophy, and the Computing Center, offers a degree in computer science. The minimum program consists of thirty hours of approved coursework.

Master of engineering in industrial engineering. This program of study is for those students whose interests are toward design rather than research. This program will provide opportunity to gain breadth of field by required course work in all areas of study within the department. In addition, a design project is carried out under the supervision of the faculty that further emphasizes breadth of field.

Doctor of philosophy in industrial engineering. This program is organized to meet the individual goals and interests of industrial engineering students who plan to engage in teaching, consulting, or research activities in industrial, governmental, or educational environments.

Each doctoral student is required to demonstrate competency in several broad fields of industrial engineering related to a personal area of interest and prepare, through formal course work and independent study, for examination in the particular area of specialization by members of the graduate faculty. A dissertation related to the field of specialization is required.

Further information about the doctor of philosophy program is contained in the Graduate School section and in a brochure available from the department.

Areas of Graduate Study

The areas of graduate study and research which are emphasized in the department are as follows:

Operations Research. Emphasis is placed on both the development and applications of operations research techniques. The program is strongly analytical in approach and content. Emphasis is placed on understanding practical problems so that suitable mathematical models can be selected or developed. Such models may be drawn from such areas as inventory theory, queueing theory, simulation, decision theory, dynamic programming, and mathematical programming theory. The operations research student is motivated by a program which emphasizes the mathematical, probabilistic, statistical, and computer sciences.

Information systems. The field of information systems embodies management information for decision-making and planning, operational systems to control man-machine activity, and methods for system analysis and design. The role of the human is stressed in data gathering, information processing and interaction with system output.

Study and research work relate to performance of computer-based systems, including evaluation criteria and cost effectiveness. Project management, simulation, data management and economic analysis principles and techniques are employed as basic tools in research activities.

The information systems laboratory is available to assist the student whose interest is in this area.

Manufacturing engineering. Graduate study in manufacturing engineering involves course work and research opportunities in specific areas related to manufacturing.

The department is currently interested in such areas as metal processing theory, automation and numerical control, manufacturing systems and management, and work systems. Additional related courses are offered in other departments in the College of Engineering and Physical Sciences.

The manufacturing processes laboratory and the computer-aided manufacturing laboratory are coupled with the course work offered in this area of emphasis.

The department offers courses during the late afternoon for the convenience of students who are employed in local industry and are taking graduate work on a part-time basis.

Course Descriptions

405. Special Topics in Industrial Engineering (3)
An intensive study of some field of industrial engineering.

408. (Acctg 408) Management Information Systems (3)
Integrated and total systems concepts for organizational data bases and information systems as applied to planning, development and implementation of computer-based management information systems. Emphasis is placed on the interaction of information systems with management planning and control. Prerequisite: an advanced course in information systems and a knowledge of programming.

410. Design of Experiments (3)
Fixed, mixed, and random models, fractional factorials, unequal cell frequencies. Sequential design for estimation and optimization. Prerequisite: a course in statistical inference.

415. Manufacturing Management (3)
Analysis of the factors entering into the development of manufacturing management philosophy; decision-making process in areas of organization, planning, operation, and control of manufacturing. Influence of the social, technical, and economic environment upon manufacturing management decisions.

416. Dynamic Programming (3)
The principle of optimality; one-dimensional processes, multi-dimensional processes, LaGrange multiplier technique. Markovian decision processes; applications.

417. Advanced Mathematical Programming (3)
Theory and applications of the extensions of linear programming. Kuhn-Tucker conditions, gradient methods of optimization, simplex-based methods of nonlinear programming, integer programming, branch and bound, zero-one discrete programming and stochastic programming. Prerequisite: a course in linear programming.

418. Simulation (3)
Application of discrete and continuous simulation techniques to model industrial systems; random number generation and testing; design of simulation experiments; simulation languages. Prerequisite: knowledge of Fortran and a course in probability theory.

428. Advanced Work Systems (3)
A critical evaluation of methods improvement and work measurement techniques. Emphasis on design of work systems, productivity improvement, and reporting systems to control work. Work sampling, construction of standard data, mathematical models of work systems.

430. (Mgt 430) Management Science Project (3) spring
An analysis of a management problem and design of its solution incorporating management science techniques. An individual written report is required. Recommended to be taken in the last semester of the program.

431. Operations Research Seminar (3)
Extensive study of selected topics in techniques and models of operations research.

433. Manufacturing Engineering Seminar (3)
Extensive study of selected topics in the research and development of manufacturing engineering techniques.

435. Mathematical Methods in Operations Research (3)
The fitting of data using splines and polynomials. The use of differential equations, difference equations, Laplace transforms, generating functions and matrices in the solution of problems arising in scheduling, inventories, maintenance, queueing and replacement. Prerequisites: calculus, linear algebra, knowledge of Fortran or equivalent.

438. Real Time Information (3)
Planning and management of real time, on-line information systems; effect of data banks, multiprocessing, time-sharing, and supervisory routines; data gathering and display techniques for interactive systems; data communications. Prerequisite: IE 310 or consent of the department chairman.

439. Applications of Stochastic Processes (3)
Introduction to stochastic processes, application in queueing theory and inventory theory. Prerequisites: a course in probability theory and IE 435.

441. Network Modeling Techniques (3)
A critical study of various network modeling techniques. Topics include: PERT, CPM, network flows, decision trees, flowgraph analysis and GERT. Emphasis will be placed on the modeling and analysis of systems using these techniques.

444. Design of Cutting Tools (3)
A study of design parameters including tool materials, tool geometry and cutting conditions for material removal operations. Emphasis will be placed on the influence of tool selection variables, on economy of operation and conformance to product requirements.

445. Production Automation (3)
Concepts and principles of automated production lines; analysis of transfer lines; partial automation; mechanized assembly; line balancing; product and process design considerations.

447. Manufacturing Systems (3)
Numerical control in manufacturing; manual and computer-assisted part programming; computer process control including monitoring and direct digital control of manufacturing operations; adaptive control and other techniques of process optimization.

450. Manufacturing Problems (3)
Discussion and solution of manufacturing problems involving several subfunctions, with emphasis on problem identification and definition; selection of techniques of analysis; procedures for evaluation of proposed solutions.

460. Engineering Project (1-6)
An intensive study of an area of industrial engineering with emphasis upon design and application. A written report is required.

461. Readings (1-3)
Intensive study of some area of industrial engineering which is not covered in general courses.

490. Research Methods Seminar (3)
Research methods in industrial engineering; discussion and critical analysis of current industrial engineering research; practice in preparation of research proposals.

Information Science

This academic program is associated administratively with the department of mathematics. Therefore, the reader is referred to that departmental entry in this section of the catalog for details of the Information Science program and courses.

Instruction and Curriculum

This department is one of three such organizations operating within the School of Education. Therefore, consult the School of Education entry in this section for a statement concerning the program of study and course descriptions.

International Relations

Professors. Oles M. Smolansky, Ph.D., *chairman*; Henderson B. Braddick, Ph.D.; Carey B. Joynt, Ph.D., Rathbone professor; Zdenek J. Slouka, Ph.D.
Associate professor. Michael R. Hodges, Ph.D.
Assistant professor. Raymond F. Wylie, Ph.D.

The field of international relations poses an unprecedented challenge to students and teachers alike and provides a stimulating focus of interest for undergraduate education.

It demands full recognition and understanding of the vast forces which are shaping the world—wars, nationalism, political ideologies, and modern technology. The leadership and responsiblities of the United States in the world arena have created a need for broadly educated men and women who possess a clear appreciation of the factors which influence the policies of nations.

Students approach the study of state behavior through three major analytical perspectives: intergovernmental relations (including courses in the theory and techniques of diplomacy, the history of modern international relations, and special seminars in international law, international institutions, and world politics), transnational relations (especially economic, ideological, and technological interactions), and area studies (European, Soviet, Middle Eastern, and Asian affairs).

The ultimate objective is to shape and develop well-informed and independent observers and participants in the field of international affairs. The flexibility of the program permits added study in history, government, economics, and other social sciences.

A special program is available in World Order Studies, a program which takes special account of the problems of world peace, transnational relations, and the impact of science and technology on international relations. Students taking this option should select twelve semester hours, in addition to their required major courses, from the following list: IR 41, 47, 101, and 301-305.

A minor program (5 courses/15 credit hours) is available for those students who wish to acquire a more systematic knowledge of world affairs in addition to their major area of study. The program permits students to survey the general field of international relations, yet acquire a deeper understanding of those aspects of the discipline directly related to their major programs.

The broad knowledge and understanding acquired can be utilized in careers in teaching, the Foreign Service of the United States and other government agencies, international business, and the legal profession.

required preliminary courses

IR 1, 2	World Politics (6)

required major courses

IR 341, 342	International Relations (6)
IR 353	International Institutions (3)
IR 354	The Atlantic Community (3)
IR 361, 362	International Law (6)

and twelve semester hours to be selected, with the approval of the department chairman, from international relations, history, and government.

Undergraduate Courses

"U" indicates that the course fulfills the upper-level distribution requirements of the College of Arts and Science. "P" indicates that the course meets preliminary requirements.

1. World Politics (3) P
Interdisciplinary approach to the modern state system, and the impact of political, economic, and social factors on world affairs; current international developments. Hodges, Wylie

2. World Politics (3) P
Major problems confronting the global system, and the policies devised by individual states and international bodies to deal with them; current international developments. Hodges, Wylie

11. European International Relations, 1815-1919 (3) P
Politics of the Great Powers; clashes of interests and international crises; development of alliances and other associations of states; wars and peace settlements; unification of Germany and Italy; influence of nationalism, the industrial revolution, and social ideologies on international relations; World War I and the peace treaties. Braddick

12. European International Relations Since 1919 (3) P
Political and strategic structure of Europe in the 1920s; rise of Nazi Germany; politics of international crises, 1935-39; World War II and the new distribution of power in Europe; development of the Cold War; European functional integration; contemporary European international problems; European relations with the United States. Braddick

21. Modern East Asia (3) P
International relations of East Asia to 1945, with emphasis on 20th century; Western impact and Eastern response; origins and course of Chinese revolution; rise and fall of Japanese empire; emergence of United States and Soviet Union as Asian powers. Wylie

22. Contemporary East Asia (3) P
International politics of East Asia since 1945, with emphasis on recent developments: origins of Cold War in East Asia; rise of China as world power; emergence of Japan as industrial giant; policies of United States and Soviet Union in Asia. Wylie

31. Middle East in World Affairs to 1945 (3) P
Political, economic, and social forces behind the rise of modern states in the Middle East; area's role in international politics from Napoleon's invasion of Egypt to the end of World War II. Smolansky

32. Middle East in World Affairs Since 1945 (3) P
Rise of Turkish, Iranian, and Arab nationalism; creation of Israel; decline of British and French power; growth of U.S. and Soviet influence; Middle East and the world's major oil producer. Smolansky

41. Science, Technology, and International Relations (3) P
Interplay between technological change and the international political system. International implications of large-scale, science-based technologies: ocean exploitation systems, weather modification, environmental alteration, air space and outer-space technologies, disease controls, and agricultural technologies. Slouka

51. American Foreign Policy Since 1945 (3) P
Recent and contemporary problems showing how changing international conditions affect the premises, concepts, and objectives of U.S. policy. Joynt

66. (CRS 66) Religion and Politics (3) P spring
Religious and theological assessments of the political order; the role of power in national and international affairs; democracy and leftist and rightist movements; authority in politics and religion; religion, justice, and injustice; the secular state and the church; war, pacifism, and alternate methods of conflict resolution.
A. R. Eckardt

80. Politics of Oil (3) P
Rise of large international oil companies since 1920 and their relations with the governments of producing and consuming countries, culminating in the formation of the Oil Producing and Exporting Countries (OPEC) and the emergence of the "energy crisis." Hodges

101. Politics of European Integration (3) U
Integration process in contemporary West Europe; European Communities as examples of peaceful community-building at supranational level. Institutional development of European Communities and the political, economic, and social dynamics of regional integration in West Europe. Hodges

133. Diplomacy of Russia to 1945 (3) U
Expansion of the Russian Empire; Russian foreign policy under the tsarist and communist governments; interaction between domestic and foreign affairs; Soviet efforts to survive in a "hostile capitalist environment." Smolansky

134. Diplomacy of Russia Since 1945 (3) U
Consolidation of gains made during and after World War II; origins of Cold War; frictions within the Communist bloc (Eastern Europe and China); nuclear arms race and striving for detente. Smolansky

181. Workshop in Research Methods (1) U
Basic methods in international relations research, with emphasis on technical methods of research design, outlining and abstracting, documentation and presentation. Designed for international relations majors in their junior year. Consent of the department chairman is required.

214. (RS 214) International Affairs and Political Theology (3) U
Theological assessments of the nation-state, the role of power in international affairs, national sovereignty and internationalism, war, pacificism, and alternative methods of conflict-resolution. A. Roy Eckardt

247. Social Forces in World Politics (3) U
Seminar in nongovernmental movements and organizations in the international political system. International functions and influence of diverse transnational forces, scientific, engineering, and professional organizations; religious and ideological movements; international interest groups and political movements, including terrorist networks. Prerequisite: IR 1 or 2 or 41, and consent of the department chairman. Slouka

Advanced Undergraduate Courses

300. Apprentice Teaching in International Relations (3) U

301. (Govt 301) International Policy-Making (3) U
Policy-making processes in the contemporary world; impact of assumptions and projections of future social and technological change on international decisions. Prerequisite: IR 1 or 2, or consent of the department chairman. Slouka

302. War and World Politics (3) U
The role of war in the modern world; changing functions of war; why nations go to war; great power wars, limited wars, civil wars, and intervention; the examples of Hitler's Germany, Japan, Korea, Vietnam, and the Arab-Israeli conflict. Joynt

303. International Peace Studies (3) U
The problem of achieving a peaceful world order; the dynamics of conflict: the role of force, law, and morals. Evaluation of the proposed solutions to violent change. The nuclear era and the challenges to order posed by scarce resources and growing interdependence. Joynt

304. Multinational Corporations As International Actors (3) U
Economic, political, and social role of multinational corporations in the international system; emphasis on relations between multinational corporations and national governments. Prerequisite: IR 1 or 2. Hodges

305. (Govt 305) Dynamics of Regional Integration (3) U
Theories of regional integration; supranational community-building in West Europe, North Atlantic area, and developing countries in Latin America, Asia, and Africa. Hodges

308. (Govt 308) Ideologies in World Affairs (3) U
Theories of ideology; nationalism and imperialism; conservatism/liberalism/socialism; Marxism/Leninism/Maoism; fascism and militarism; Third World ideologies; current ideological trends. Wylie

311. World Affairs, 1919-1945 (3) U
International relations between the world wars; structure of the state systems in 1919-22; ideals and realities of the League of Nations; challenge of Nazi Germany, Japan, Fascist Italy, and Soviet Russia; appeasement; crises of the 1930s; and World War II. Braddick

312. World Affairs Since 1945 (3) U
International relations after World War II; its impact on the state system; Cold War and development of bipolar international politics; the United Nations as an instrument for international order and security; decline of the colonial system and emergence of new states; development of Communist China and Western Europe as new power centers; and contemporary problems in international relations. Braddick

318. (Govt 318) Communist Political Systems (3)U
Examination of Communist political systems outside the USSR and the operations of nonruling Communist parties.

321. China in World Affairs (3) U
Role of China in world affairs, emphasizing triangular relationship involving China, United States, and Soviet Union. Other topics include: Maoist ideology and domestic politics; making of foreign policy; relations with Japan and Europe; policies toward the Third World; current and future problems. Wylie

322. (Govt 322) Politics of Developing Nations (3)U
Theories of political development in non-Western areas: modernization and nation building. Field studies and methods; contributions of related disciplines such as sociology and psychology.

324. (Govt 324) Political Systems in Transition (3) spring U
The responses of selected non-communist states to contemporary problems. May be repeated for credit with consent of the department chairman. Yates

332. Contemporary Soviet Policy in the Middle East (3) U
Underlying causes, interests and motivations of Soviet policy in the Middle East during the post-Stalin era; effect on activities of Khrushchev and Brezhnev of superpower relations, regional politics and Russia's traditional interests in the Middle East. Smolansky

334. Soviet Union in World Affairs (3) U
Objectives, strategy and tactics of Soviet diplomacy: Russia's status as a superpower. Prerequisite: IR 134 or consent of the department chairman. Smolansky

341. International Relations (3) U
Contemporary theories and basic concepts of world politics; application to historic and current issues of international relations. Joynt

342. International Relations (3) U
Role of force in international politics: deterrence, limited war, problems of arms control and disarmament; crisis diplomacy. Joynt

353. International Institutions (3) U
Theory and functioning of the League of Nations and the United Nations; problems of peace and security; regional and functional organizations. Braddick

354. Atlantic Community (3) U
Political, cultural, and strategic influences affecting relationship between Western Europe, United States, and Canada; NATO; strains in the Community and prospects. Braddick

361. International Law (3) U
Foundation and structure of international law; sources of international legal rights and obligations; rules governing coexistence, interaction, and conflict of states; international law-making and adjudication. Slouka

362. International Law (3) U
Function of international law in world politics; rise and demise of international legal norms: social, political, economic, cultural and technical forces shaping world legal order. Prerequisite: IR 361. Slouka

371. Readings in International Relations (3) U
Directed course of reading intended for students with special competence or interest in fields of international relations not fully covered by regular course offerings. May be repeated for credit.

372. Readings in International Relations (3) U
Continuation of IR 371. May be repeated for credit.

381. Special Topics (3) U
Intensive study of some aspects of international politics not covered in another course.

382. Special Topics (3) U
Continuation of IR 381.

391. Teaching of International Relations (3) U
Fundamental principles and problems of international relations, including current applications. Open only to present and prospective junior and senior high school teachers. Slouka

Italian

See the section under Modern Foreign Languages for course descriptions.

Journalism

This academic program is a division of the department of English. Therefore, the reader is referred to that entry in this section of the catalog for details of the journalism program and courses.

Jewish Studies

See Special Interdisciplinary Minors, College of Arts and Science, Section III. For Modern Hebrew course descriptions, see Modern Foreign Languages in this section.

Languages

See course descriptions under Modern Foreign Languages, listed alphabetically in the following pages.

Latin-American Area Studies

Consult Special Interdisciplinary Programs, College of Arts and Sciences, Section III. For Spanish, see Modern Foreign Languages course listings in pages which follow.

Law

See the departmental listing for Accounting and Law at the beginning of this section.

Management, Finance and Marketing

Professors. Carl R. Beidleman, Ph.D., Dubois professor of finance; James B. Hobbs, D.B.A.; Eli Schwartz, Ph.D.; Max D. Snider, M.B.A., *associate dean* of the College of Business and Economics.
Associate professors. John W. Bonge, Ph.D., *chairman*; James E. Hansz, Ph.D.; Leon E. Krouse, Ph.D.; Benjamin Litt, Ph.D.; Bruce M. Smackey, Ph.D.
Assistant professors. Stephen G. Buell, Ph.D.; James A. Greenleaf, Ph.D.; Raymond L. Horton, D.B.A.; John E. Stevens, Ph.D.
Instructor. John L. Tucker, M.B.A.
Adjunct Lecturers. Marc J. Dollinger, M.B.A.; Dale F. Falcinelli, M.S.

Programs and Courses in Finance

This major is in the College of Business and Economics. Fifteen credit hours are required beyond the core listed on page from the following:

Fin 323	Investments (3)
Fin 324	Security Analysis (3)
Fin 326	Problems in Financial Management (3)
Fin 330	Financial Flows and Markets (3)
Fin 331	Bank Management (3)
Fin (Eco) 332	Monetary-Fiscal Policy (3)
Fin (Eco) 340	International Finance (3)
Fin (Eco) 353	Public Finance: Federal (3)
Fin (Eco) 354	Public Finance: State and Local (3)
Fin 371	Directed Readings (1-3)
Fin 372	Special Topics (1-3)

For Advanced Undergraduates and Graduates

225. Business Finance (3) fall-spring
An introductory course in corporation finance which stresses the management approach as it applies to asset management and capital structure. Emphasis is placed on financial policies regarding the acquisition of funds and their allocation to competing assets within the firm. Problems are used to illustrate the principles involved. Prerequisites: Eco 45, Eco 105, Math 41 and 44, Acctg 51.

300. Apprentice Teaching in Finance (1-3) fall-spring
See the introductory portion of this section for a description of apprentice teaching.

323. Investments (3) spring
An introduction to the investment process. The nature of risk and the form of returns to financial assets are examined. Investor objectives, attitudes and constraints are considered in conjunction with the risk-return matrix as the basis for investment decisions. Problems of timing, market characteristics and portfolio management also are treated. Prerequisite: Fin 225. Krouse

324. Security Analysis (3) fall
Examination of factors which influence the value of financial securities, including earnings forecasts and expectations, uncertainty, investor attitudes, required returns, and the supply and demand for securities and funds. Also considered are market factors, technical approaches, timing, screening, and portfolio implications. Prerequisites: Fin 225, Acctg 111, Eco 119, Eco 229. Beidleman

326. Problems in Financial Management (3) spring
An extension of the introductory business finance course where major topic areas such as capital budgeting, working capital management, leasing, mergers, etc., are examined in depth. Cases and more complex problems are used to illustrate the concepts covered and their application to real-world situations. Prerequisite: Fin 225. Schwartz, Tucker

330. Financial Flows and Markets (3) alternate years
The nature and role of financial intermediaries in financial markets from a flow-of-funds perspective. Emphasis is on the interrelationships between financial and nonfinancial flows in the economy, and the forecasting of interest rate structures. Prerequisites: Fin 225 and Acctg 111. Krouse, Tucker

331. Bank Management (3) alternate years
The management of bank resources and assets within the framework of economic and legal constraints. Particular attention is given to optimizing the objectives of profitability, safety and liquidity. Completion of a project in bank management is required of each student. Prerequisites: Fin 225 and Eco 229. Krouse, Tucker

332. (Eco 332) Monetary-Fiscal Policy (3)
A course devoted to the study of monetary, credit and fiscal policies of governments and central banks with particular reference to the policies of the U.S. Treasury and the Federal Reserve System. Current problems receive special emphasis. Prerequisite: Eco 19 or equivalent.

333. Multinational Business Finance (3)
Examination of the issues that underlie the investment, financing, and dividend decisions of multinational firms. Consideration is given to current transactions in foreign currencies, direct and portfolio investment and associated risk management when dealing in foreign countries. Prerequisite: Fin 326 or Fin 331. Beidleman

340. (Eco 340) International Finance (3)
The balance of payments and the theory of disturbances and adjustment in the international economy; international monetary policies.

353. (Eco 353) Public Finance: Federal (3)
A course dealing with governmental expenditures and revenues, the economics of taxation, and government administration.

354. (Eco 354) Public Finance: State and Local (3)
The major issues regarding revenues, expenditures, debit and budgeting policy are examined in the light of fiscal principles and economic effects. Particualar attention is given to current practices in Pennsylvania and contiguous states. Prerequisite: Eco 353.

371. Directed Readings (3)
A course of readings in various fields of finance, designed for the student who has a special interest in some field of finance not covered in scheduled courses. Prerequisite: consent of the department chairman. May be repeated.

372. Special Topics (1-3)
Special problems and issues in finance for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of instructor and students. Prerequisite: consent of the department chairman. May be repeated.

For Graduate Students

401. Managerial Finance (3)
An entry-level master of business administration course which examines the decisions involved in capital budgeting, working capital management, financing of a firm's assets, divident policy, valuation and the cost of capital. This course is designed to meet this background requirement of a student enrolled in the master of business administration program. Prerequisites: Eco 405, Eco 417 and Acctg 415.

415. (Eco 415) Capital and Interest Theory (3) alternate years
Examination of theories of interest and capital. The following topics are investigated: present value theory; investment valuation under certainty and risk; term structure of interest rates; the theory of savings, cost of capital, and capital formation. Prerequisite: consent of the department chairman. Schwartz

421. Financial Management (3) fall-spring
A decision-oriented course which integrates the theory and practice of business finance. Among the topics included are working capital management, capital expenditure decisions, functions of the capital markets, mergers, dividend policy, capital structure, valuation and the cost of capital. The effect of uncertainty on the problems of financial analysis is considered. Readings, case problems and decision-oriented reports are utilized to illustrate the principles involved. Prerequisite: Fin 401 or equivalent.

425. (Eco 425) Public Finance (3) spring; even-numbered years
Major issues in taxation of income consumption, and capital; principles of government debt management; budgeting and fiscal planning for economic stability and growth.

431. Advanced Investment Analysis and Portfolio Management (3) fall
This course is designed to integrate the theoretical and empirical aspects of the economic environment with the investment analysis associated with portfolio management programs of financial intermediaries and individuals. Particular emphasis is given to the current impingements of the economic environment upon portfolio management decisions. Prerequisite: Fin 421. Greenleaf

442. (Eco 442) Foreign Trade Management (3) spring, odd-numbered years
Current problems of foreign operations, including channels of export in foreign markets, export and import financing, foreign investments, policies of government and international agencies as they affect foreign operations.

444. (Eco 444) Banking and Monetary Policy (3)
Description and analysis of the U.S. monetary and banking structure. The supply and demand for funds. Financial markets. Central bank controls; monetary theory and policy. Prerequisite: a course in money and banking.

451. Quantitative Financial Models (3) alternate years
A survey of quantitative models as they relate to financial theory

and applications. Finance topics include capital budgeting, portfolio selection, security evaluation, cash management, inventory policy and credit analysis. Prerequisite: Fin 421. Greenleaf

471. Directed Readings (1-3)
Graduate readings in finance not covered in regularly scheduled coursework. Prerequisite: consent of the department chairman. May be repeated.

472. Special Topics (1-3)
Special problems and issues in finance for which no regularly scheduled graduate course work exists. When offered as group study, coverage varies according to interest in finance. Prerequisite: consent of the department chairman. May be repeated.

Management Program and Courses

This is a major in the College of Business and Economics. Fifteen credit hours are required beyond the core listed on page 42, from the following:

required courses

Mgt 302	Quantitative Models/Conceptual (3)
Mgt 321	Organization Behavior Workshop (3)

electives
In addition, the management major selects one of the three options shown below. An asterisk denotes courses that are strongly recommended.

quantitative (select three courses)

*Mgt 304	Quantitative Models/Applications (3)
Mkt 312	Marketing Research (3)
Acctg 324	Cost Accounting (3)
Eco 352	Advanced Statistical Methods (3)

behavioral (select three courses)

*Mgt 316	Organizational Decision Processes (3)
Mgt 331	Industrial Relations (3)
Mkt 315	Consumer Behavior (3)
SR 312	Small Groups (3)

general management (select three courses)

Mgt 311	LUMAC (3)
*Mgt 316	Organizational Decision Processes (3)
*Mkt 319	New Product Planning (3)
*Fin 326	Problems in Financial Management (3)
Eco 346	Business Cycles and Forecasting (3)

For Advanced Undergraduates and Graduate Students

269. Management of Operations in Organizations (3) fall-spring
Study of the design, operation and control of activities necessary to generate the goods or services of profit and nonprofit organizations. Includes examination of basic concepts and quantitative modes used in operations. Eco 45, Math 44. Stevens, Smackey

270. Conceptual Foundations of Organizational Theory and Behavior (3) fall-spring
A study of formal organizations as ongoing systems and the behavior of people within them. Systems examined include: a bureaucratic-rationality model; a behavioral-social model; and an adaptive-contingency model.

300. Apprentice Teaching in Management (1-3) fall-spring

301. Business Management Policies (3) fall-spring
Case study of business problems and the formulation of policies, strategies and tactics to resolve those problems from the viewpoint of general management. Emphasis on long-range goal attainment, policy formulation, and administrative implementation for particular functional areas and the total firm. Prerequisites: senior standing in the College of Business and Economics, and completion of the college core.

302. Quantitative Models-Conceptual (3) fall-spring
Survey of various quantitative methodologies and their use in business, economics and other areas. Specific subject areas include: classical optimization techniques, mathematical programming, including linear programming, decision theory, game theory, simulation and network models. Prerequisites: Eco 105, Acctg 111 and Mgt 269.

304. Quantitative Models-Applications (3) spring
Extension and application of selected topics covered in Mgt 302. Development of term projects to solve practical problems. Prerequisite: Mgt 302. Greenleaf

306. Entrepreneurship and Business Policy (3) spring
A case study of the problems of creating new ventures or managing family-owned businesses. Integrates knowledge acquired in other courses and stresses development of strategic and administrative policies for particular functions and the company as a whole. Prerequisites: senior standing, completion of College of Business and Economics core and Mgt 311, as well as approval of the department chairman. Students may not receive credit for both Mgt 306 and Mgt 301. Satisfies the Mgt 301 or Eco 333 core requirement. Bonge

311. LUMAC (Management Assistance Counseling) (3) fall-spring
A field studies course primarily for business and economics majors. Students acquire experience in accounting, financial control, marketing and management under the faculty's supervision by providing management assistance to small businesses in the Lehigh Valley. Students work in small groups on a direct basis with owners. Prerequisite: junior standing in the College of Business and Economics and consent of the department chairman. Course may be repeated once for credit.

314. (SR 314) Organizational Structure and Communication (3) alternate years
Models of the formal and informal communication structures of business, industrial, and governmental organizations and the consequences of these structures on morale and productivity. Freeman

316. Organizational Decision Processes (3)
Examination of managerial decision-making processes in formal organizations. Operating decisions, negotiated decisions and strategic decisions are analyzed through individual and group activities. Primary focus on necessary imputs for effective organizational decisions. Prerequisites: Mgt 269 and Mgt 270. Bonge, Litt

321. Organizational Behavior Workshop
Study of psychological aspects of individual behavior, interpersonal transactions, behavioral processes in small work groups, and the entire organization as an ongoing system. Techniques include motivational analysis, role-playing, nonverbal interactions, group problem solving and organizational simulations. Prerequisites: Mgt 270 and permission of the department chairman.

331. Industrial Relations (3) fall
Interdisciplinary consideration of conflict and conflict resolution procedures in the industrial and related settings, emphasizing behavioral aspects of work roles in intergroup relationships, collective bargaining in private and public sectors, grievance machinery terminating in arbitration, mediation, fact-finding and other aspects of public emergency dispute settlement. Prerequisite: Mgt 269 or equivalent.

371. Directed Readings (1-3)
Readings in various fields of management, designed for the student who has a special interest in some field of management not covered by the regularly scheduled courses. Prerequisite: consent of the department chairman. May be repeated.

372. Special Topics (1-3)
Special problems and issues in management for which no regularly scheduled course work exists. When offered as group

study, coverage varies according to interests of instructor and students. Prerequisite: consent of the department chairman. May be repeated.

For Graduate Students

402. Operations Management (3) spring
Focus on the operations function from the perspective of general management. Emphasis is on the development of operations-related models and the formulation and implementation of operations policy in the context of the firm's over-all strategy. This course is designed to meet this background requirement of a student enrolled in the master of business administration program. Prerequisites: Eco 417 and Mgt 441.

412. Organization Structures and Processes (3) spring
An examination of the structure and processes of organizations. The traditional bureaucratic model of managing work and information flow is contrasted with the behavioral decision-making model of the firm. A synthesis of these perspectives is sought through a study of the contemporary theory of organization. Classroom activity centers around the discussion of research-based theories and the analysis of case problems. Prerequisite: Mgt 413 or equivalent. Bonge

413. Organizational Behavior (3)
The study of organization behavior concepts integrated with experiential learning of selected topics such as psychological contract, motivation, interpersonal perception and communication, group structure and processes, leadership, managerial style, and organizational change. This course is designed to meet this background requirement of a student enrolled in the master of business administration program. Not available for students who have taken Mgt 270 or Mgt 321.

417. (IE 417) Advanced Mathematical Programming (3)
Theory and applications of the extensions of linear programming. Tucker-Kuhn conditions, gradient methods of optimization, simplex-based methods of nonlinear programming, integer programming, branch and bound, zero-one discrete programming and stochastic programming. Prerequisite: a course in linear programming.

418. Analytical Methods in Management (3) alternate years
Application of management science methods to industrial and commercial problems. Scientific method, decision theory, linear programming, inventory control, regression analysis, forecasting, simulation, and related areas are examined in the context of accounting, finance, marketing, and manufacturing. Prerequisite: Mgt 302.

423. Corporate Enterprise: Concepts and Issues (3)
A study of contemporary social issues relevant to corporate enterprise. A framework is developed around concepts drawn from political science, economics, business history, law and the behavioral sciences and is used to analyze the benefits and social costs of corporations. Issues such as corporate power, lifestyles, work and leisure, resources and pollution, and the role of government are examined. Litt

430. (IE 430) Management Science Project (3)
As an individual or as a member of a small group, an analysis is made of a management problem and the design of its solution is made incorporating management science techniques. An individual written report is required. Recommended that it be taken in the last semester of the master of science in management science program.

441. Quantitative Methods in Business and Economics (3)
A survey of various quantitative methodologies and applications. Subject areas include: classical optimization techniques, mathematical programming, simulation, decision theory, game theory, network models and statistics. This course is designed to meet this background requirement of a student enrolled in the master of business administration program. Prerequisite: Eco 417.
Greenleaf

451. Managerial Policy and Decision-Making (3) fall-spring
Integration of theory and analytic techniques through intensive investigation of complex organizational, strategic and financial problems in industrial and nonbusiness entities. A case study approach is used. Prerequisites: graduate-level exposure to accounting, economics, finance, management and marketing. A master of business administration candidate should take the course near the end of the MBA program. Hobbs

471. Directed Readings (1-3)
Graduate readings in management not covered in regularly scheduled course work. Prerequisite: consent of the department chairman. May be repeated.

472. Special Topics (1-3)
Special problems and issues in management for which no regularly scheduled graduate course work exist. When offered as group study, coverage will vary according to the interests of instructor and students. Prerequisite: consent of the department chairman. May be repeated.

Marketing

This is a major in the College of Business and Economics. Fifteen credit hours are required beyond the core listed on page 42, from the following:

required courses

Mkt 313	Marketing Communications (3)
Mkt 312	Marketing Research (3)

elective courses
Three courses (nine credit hours) from the following:

Mkt 315	Consumer Behavior (3)
Mkt 316	Advertising (3)
Mkt 317	Industrial Marketing (3)
Mkt 319	New Product Planning (3)
Mkt 320	International Marketing (3)
Mkt 371	Directed Readings (1-3)
Mkt 372	Special Topics (1-3)

Other approved courses may be used as marketing electives depending upon student's career orientation. Mgt 302, Eco 339, Acctg 324, and Fin 326 are examples.

For Advanced Undergraduates and Graduate Students

211. Contemporary Marketing (3) fall-spring
The course examines contemporary marketing from a managerial perspective. It emphasizes the design of marketing programs given the considerations of such background variables as consumer behavior, the social and cultural environment, the economic environment, market segmentation, the nature of demand, and industry structure. Prerequisite: Eco 105.

300. Apprentice Teaching in Marketing (1-3) fall-spring

312. Marketing Research (3) fall-spring
Use of quantitative and qualitative information in routine and nonrecurring decision-making. Topics include statistical design of marketing studies, model building, analysis of research studies, and the development of marketing information systems. Case problems and presentation of student research projects examine problems in communicating research results. Prerequisites: Eco 45 and Mkt 211. Hansz, Horton, Smackey

313. Marketing Communications (3) fall-spring
The course considers the communication-promotion decision processes of organizations. The effects of source, message and media variables on audience response to communication campaigns and the interactions among these variables are examined. Strong emphasis is given the promotion model consisting of the roles of personal selling, sales promotion, publicity, and advertising in marketing. Prerequisite: Mkt 211.

315. Consumer Behavior (3) fall
Examination of principal theories which the fields of psychology, social psychology, anthropology and economics contribute toward understanding the behavior and motivations of consumers. Topics include consumer needs and wants; learning theory; the perceptual process; decision-making processes; communication; search behavior; market segmentation and product differentiation; and the adoption and diffusion of innovations. Prerequisites: Mkt 211 and Mkt 312. Horton

316. Advertising (3) spring
An intensive study of advertising from a managerial perspective. The critical analysis of specific advertising campaigns and the societal implications of advertising are considered. Prerequisite: Mkt 313.

317. Industrial Marketing (3) fall
Analysis of marketing and sales problems unique to manufacturers of industrial products. Focus on organization and productivity of sales force, product line policies, pricing strategies, buyer requirements, customer service, and the use of formal proposals. Prerequisites: Mkt 211 and Fin 225.
Smackey

319. New Product Planning (3) spring
An advanced marketing course specializing in the organization and management of marketing activities related to the development of new and improved products. The role of marketing research and preproduction testing in the commercialization process. Application of simulation and risk analysis to the screening of research and development projects. Prerequisites: Mkt 211 and Fin 225. Smackey

320. International Marketing (3) spring
The variety of overseas market entry strategies a firm might employ are considered. Indirect methods for expanding into markets outside of the United States are emphasized: exporting, the use of agents, licensing, and joint ventures. A project assessing the overseas market potential and selecting the proper distribution channel is required. Prerequisites: Fin 225 and Mkt 211. Hansz

371. Directed Readings (1-3)
Readings in various fields of marketing, designed for the student who has a special interest in some field of marketing not covered in regularly scheduled courses. Prerequisite: consent of the department chairman. May be repeated.

372. Special Topics (1-3)
Special problems and issues in marketing for which no regularly scheduled course work exists. When offered as group study, coverage will vary according to the interests of the instructor and students. Prerequisite: consent of the department chairman. May be repeated.

For Graduate Students

407. Marketing Strategy (3)
An overview of the role of marketing in organizations. Particular emphasis is placed upon the design of marketing strategy, given such considerations as consumer behavior, the social-cultural environment, legal-political environment, market segmentation, the nature of demand, and industry structure. This course is designed to meet this background requirement of a student enrolled in the master of business administration program. Prerequisite: Eco 405.

411. Marketing and the Multinational Firm
The stages in the development of multinational firms are developed from initial use of marketing intermediaries through the evolution of overseas production and marketing to the eventual integration of the multinational firm. Students progress through each of these phases utilizing the medium of computer simulation. Their ultimate responsibility is the design and management of their own multinational firm. Prerequisites: Fin 401, Mkt 407 and Mgt 441, or equivalent. Hansz

450. Marketing Planning and Organization (3) fall
An advanced marketing management course emphasizing marketing analysis, planning and control of those factors that firms use to realize market opportunities and react to competitive forces. The marketing audit is considered as a strategic tool for maintaining an organization's pricing, product, promotion and distribution mix. Prerequisite: Mkt 407 or equivalent. Hansz, Smackey

471. Directed Readings (1-3)
Graduate readings in marketing not covered in regularly scheduled courses. When offered as group study, coverage varies according to the interests of the instructor and students. Prerequisite: consent of the chairman. May be repeated.

472. Special Topics (1-3)
Special problems and issues in marketing for which no regularly scheduled graduate course work exists. When offered as group study, coverage varies according to the interests of the instructor and students. Prerequisite: consent of the department chairman. May be repeated.

Mathematics

Professors. Gilbert Stengle, Ph.D., *chairman;* Edward F. Assmus, Jr., Ph.D.; Dominic G.B. Edelen, Ph.D.; Bhaskar K. Ghosh, Ph.D.; Samuel L. Gulden, M.A.; Theodore Hailperin, Ph.D.; Chuan-Chih Hsiung, Ph.D.; Samir A. Khabbaz, Ph.D.; Jerry P. King, Ph.D.; Gregory T. McAllister, Ph.D.; Murray Schechter, Ph.D.; Albert Wilansky, Ph.D.
Associate professors. Donald M. Davis, Ph.D.; Bennett Eisenberg, Ph.D.; Clifford S. Queen, Ph.D.; Viswanatha R.G. Rao, Ph.D.; Gerhard Rayna, Ph.D.; Andrew K. Snyder, Ph.D.; David Trutt, Ph.D.
Assistant professors. David Johnson, Ph.D.; Paul E. Cohen, Ph.D.;
Visiting assistant professors. Carlie Coats, Ph.D.; Vernon Eagle, Ph.D.;
Lecturers. Bruce Dodson, Ph.D.; Donna Kumagi, Ph.D.

Bachelor of Arts in Mathematics

Mathematics is the universal language of science. The major in mathematics prepares the student to use mathematics for expressing and analyzing relationships in a wide variety of disciplines. These include the exact sciences, the social sciences, business, and pure mathematics itself. The program emphasizes fundamental principles and the mastery of techniques required for the effective use of mathematics.

Special programs can be arranged for students interested in computer science, actuarial science, statistics, or applications to other sciences.

required preliminary courses

Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry and Calculus II (4)
Math 23	Analytic Geometry and Calculus III (4)

or, in place of the three above, both of the following courses:

Math 31	Calculus (4)
Math 32	Calculus (4)

required major courses

Math 205	Linear Methods (3)
Math 219	Principles of Analysis (3)
Math 220	Principles of Analysis (3)
Math 316	Complex Analysis (3)
Math 243	Algebra (3)
Math 244	Algebra (3)
	major electives (12)

Note: Approval of the electives by a designated representative of the department is required. They need not all be courses offered by

the mathematics department. They must include at least one of the following: Math 307, 309, 320 and 332.

Students with an interest in applied mathematics are encouraged to choose for some of their major electives mathematically oriented 200- or 300-level courses offered by other departments.

Students interested in actuarial science are advised to include Math 230, 309, 334, and 336 among their major electives. For information on preparation for taking examinations of professional actuarial societies, students may consult their mathematics adviser.

For students especially interested in computer science, the substitutions Math 208 for Math 316 and CIS 317 for Math 244 are acceptable. It is suggested that their electives include some or all of the courses listed under Minor in Computer Science.

Bachelor of Science in Statistics

The bachelor of science degree program in statistics is interdisciplinary, and is a cooperative effort of faculty members from several departments. A student participating in the program is enrolled in the department of mathematics and is assigned a faculty adviser whose departmental affiliation depends on the student's needs and interests.

Statistics is concerned with the development and application of methods and techniques for collecting, analyzing and interpreting data in such a way that the reliability of the conclusions can be quantified. It forms a fundamental tool in all scientific inquiry. Applied statisticians work in fields such as biostatistics, demography, econometrics, and quality control.

Requirements

- English 1 and 2
- at least thirty hours of electives in the humanities, social sciences, and natural sciences, of which at least eighteen are in the humanities.
- thirty hours of electives from at least two allied fields or fields of application such as mathematics, computing and information science, biology, and chemistry.
- fifty-four hours of required courses as described below.

required preliminary courses
Math 21, 22 and 23; either Math 7 or Eco 45
required major courses
Math 201, 205, 208, 219, 309, 310, 313, 334 and 374
CIS 11
Educ 388
IE 335, 336

electives
At least thirty hours of electives are chosen from two or three fields of application, but not more than eighteen hours from any single field.

No student in the program may take more than twenty-five percent of total university course work in business courses (i.e., economics, accounting and law, or management, finance and marketing).

Minors in Mathematics

These are six minor programs offered in the department of mathematics. The courses normally required are listed below. For substitutions, consult the department chairman.

minor in pure mathematics
Math 23, 219, 243, and 244
Math 220 or 316

minor in applied analysis
Math 23, 205, 208, 230; and two of the following:
Math 320, 322, 323, 332

minor in probability and statistics
Math 23 or 44;
Math 7 or 42 or 231;
and three of the following:
Math 201, 309, 310, 313, 334.

minor in actuarial science
Math 230, 231, 235, and any two of the following: Math 309, 334, 336.

minor in computing science
CIS 11, Math 23, 205; CIS 12 or 102 or 105; Math 230 or 243 or CIS 317 or 362

minor in astronomy
Phys 11, Math 21, and Astr 2; Math 22 or Readings (Math 171 or 371); Astr 211 or 221; Astr 232 or 242

Undergraduate Courses

7. Elements of Statistics (3) P fall-spring
Statistical data and frequency distributions; probability, random variables, and sampling distributions; estimation, confidence intervals, and hypothesis testing; regression and correlation; analysis of variance. Illustrations from biological, engineering, physical and social sciences.

21. Analytic Geometry and Calculus I (4) UP fall-spring
Functions and graphs; limits and continuity; derivative and differential; indefinite and definite integral; logarithm and exponential.

22. Analytic Geometry and Calculus II (4) UP fall-spring
Trigonometric and hyperbolic functions; integration; vector algebra and calculus; solid analytic geometry. Prerequisite: Math 21.

23. Analytic Geometry and Calculus III (4) UP fall-spring
Series; Taylor's Theorem; approximations; partial derivatives, multiple integrals; line and surface integrals; differential equations. Prerequisite: Math 22.

Math 31 and 32 constitutes an accelerated calculus sequence which is equivalent to Math 21, 22 and 23.

31. Calculus (4) UP fall
Functions and graphs; limits and continuity; derivative and differential; indefinite and definite integral; logarithm, exponential, trigonometric and hyperbolic functions; integration; vector algebra and calculus. Math 31 may be used in place of Math 21 to satisfy prerequisites. Prerequisite: consent of the chairman.

32. Calculus (4) UP spring
Vector calculus; solid analytic geometry; series; Taylor's Theorem; approximations; partial derivatives; multiple integrals; line and surface integrals; differential equations. Math 32 may be used in place of Math 23 to satisfy prerequisites. Prequisite: Math 31.

Math 41 through 44 are designed primarily for students of the Biological, Management, and Social Sciences (BMSS). Math 44 normally should be taken in the semester following Math 41. Math 42 and 43 may each be taken at any time.

41. BMSS Calculus (3) UP fall-spring
The Riemann integral, the derivative, limits and continuous functions, the mean value theorem, the fundamental theorem of the calculus, antiderivatives, applications of the integral, maxima and minima, infinite sequences and series, partial derivatives.

42. BMSS Probability (3) UP spring
Sets, functions, counting methods, probability spaces, conditional probability and independence, random variables, continuous probability spaces, some useful probability distributions—binomial, hypergeometric, Poisson, uniform, exponential and normal.

43. BMSS Linear Algebra (3) UP fall
Matrices, vectors, vector spaces and mathematical systems, special kinds of matrices, elementary matrix transformations, systems of linear equations, convex sets, introduction to linear programming.

44. BMSS Calculus (3) UP fall-spring
Functions of several variables, applications of partial derivatives, extreme values of functions, Lagrangian multipliers, complex variables and exponentials. Euler's formula, calculus of trigonometric functions, linear difference and differential

equations, systems of linear equations, numerical solution of differential equations. Prerequisite: Math 41 or 21 or consent of the department chairman.

61. Logical Methods (3)
Informal survey of set theory and logic. Manipulation of logical formulas. Methods and terminology of mathematics: formal languages, Boolean algebras, order relations, equivalence classes, and induction.

171. Readings (1-3) UP fall-spring
Study of a topic in mathematics under individual supervision. Intended for students with specific interests in areas not covered in the listed courses. Prerequisite: consent of the department chairman. May be repeated for credit.

For Advanced Undergraduates and Graduate Students

For students who have not taken their elementary mathematics at Lehigh, the prerequisites for certain advanced courses are stated in terms of the number of semester hours of calculus.

201. Mathematical and Computer Modeling (3) fall, '79, '81
Mathematical and computer solution of differential equations; construction and analysis of models for complex systems. Applications to problems in ecology, the social sciences, and business. Necessary techniques for the use of the computer. Prerequisite: Math 22 or 44.

205. Linear Methods (3) UP fall-spring
Matrices; systems of linear equations; determinants and rank; characteristic roots; linear differential equations; eigenvalue problems; analytic functions; Bessel's equation. Designed for undergraduates in science and engineering. Prerequisite: Math 23 or Math 32.

208. Complex Variables (3) fall-spring
Functions of a complex variable; calculus of residues; contour integration; applications to conformal mapping and Laplace transforms. Prerequisite: Math 23, Math 32, or nine semester hours of differential and integral calculus.

219. Principles of Analysis I (3) UP fall-spring
The real number system; limits; continuous functions; differentiation; integration; infinite series. Prerequisite: Math 23, Math 32 or nine semester hours of differential and integral calculus.

220. Principles of Analysis II (3) UP fall-spring
Continuation of Math 219. Absolute and uniform convergence; functions of several variables; line and surface integrals; implicit functions. Prerequisite: Math 219.

230. Numerical Analysis (3) UP fall
Difference calculus and interpolation, numerical quadrature, numerical solution of nonlinear equations, and difference methods for ordinary differential equations. Some familiarity with a computer programming language is necessary. Prerequisite: Math 205 previously or concurrently.

231. Probability and Statistics (3) UP fall-spring
Probability and distribution of random variables; populations and random sampling; *t*, chi-square, and F distributions; estimation and tests of hypotheses; correlation and regression theory of two variables. Prerequisite: Math 23, Math 32, or nine semester hours of calculus.

235. Actuarial Science (3) UP fall, even-numbered years
Selected topics from measurement of interest, annuities, bonds, amortization schedules and sinking funds. Introduction to single-life functions. Relevant to Part III of the examination offered by the Society of Actuaries. Not an approved elective for mathematics major programs. Prerequisite: Math 231 or consent of the department chairman.

243. Algebra (3) UP fall-spring
An introduction to the basic concepts of modern algebra beginning with group theory and including ring theory, linear algebra, and field theory. Prerequisite: Math 205.

244. Algebra (3) UP fall-spring
A continuation of Math 243. Prerequisite: Math 243.

251. Mathematical Methods (1-4) UP
An introductory survey of topics in analysis for graduate students in fields other than mathematics. Topics may include: differential equations, techniques of series expansion, numerical methods, matrix and vector analysis, complex variables, calculus of vector fields. Formal applications are emphasized. Prerequisites: graduate standing and consent of the department chairman. With consent of the department chairman, may be repeated for credit.

302. Advanced Calculus and Exterior Differential Forms (3) UP spring
Implicit function theorem, exterior algebra, exterior differential forms, Stokes' theorem. The Frobenius and Darboux theorems with applications to topics selected from partial differential equations, electromagnetic theory, classical mechanics, differential geometry, and thermodynamics. Prerequisite: Math 205.

303. Mathematical Logic (3) UP fall, odd-numbered years
A course, on a mathematically mature level, designed not only to acquaint the student with the logical techniques used in mathematics but also to present symbolic logic as an important adjunct in the study of the foundations of mathematics. Cohen, Hailperin

304. Axiomatic Set Theory (3) UP spring
A development of set theory from axioms; relations and functions; ordinal and cardinal arithmetic; recursion theorem; axiom of choice; independence questions. Prerequisite: Math 219 or consent of the department chairman. Cohen, Hailperin

307. General Topology I (3) UP fall
An introductory study of topological spaces, including metric spaces, separation and countability axioms, connectedness, compactness, product spaces, quotient spaces, function spaces. Prerequisite: Math 219.

308. Algebraic Topology I (3) UP spring
Polyhedra, fundamental groups, simplicial and singular homology. Prerequisites: Math 307 and Math 327.

309. Theory of Probability (3) UP fall-spring
Probabilities of discrete and continuous sample spaces; events on a discrete sample space; random variables and probability distributions; transformations; simplest kind of law of large numbers and central limit theorem. The theory is applied to problems in physical and biological science. Prerequisite: Math 23, Math 32, or nine semester hours of differential and integral calculus. Ghosh

310. Probability and its Applications (3) UP spring
Continuation of Math 309. Random variables, characteristic functions, limit theorems; stochastic processes, Kolmogorov equations; Markov chains, random walks; time series. Prerequisite: Math 309 or consent of the department chairman. Eisenberg, Ghosh

313. Nonparametric Statistics (3) fall, even-numbered years
Order and rank statistics; tests based on runs, signs, ranks, and order statistics; chi-square and Kolmogorov-Smirnov tests for goodness of fit; the two-sample problem; measures of association in bivariate populations; confidence and tolerance intervals. Prerequisites: Math 231, or Math 309, or both Math 7 and Math 23.

316 Complex Analysis (3) UP spring
Concept of analytic function from the points of view of the Cauchy-Riemann equations, power series, complex integration, and conformal mapping. Prerequisite: Math 219.

320. Ordinary Differential Equations (3) UP spring
The analytical and geometric theory of ordinary differential equations, including such topics as linear systems, systems in the complex plane, oscillation theory, stability theory, geometric theory of nonlinear systems, finite difference methods, general dynamical systems. Prerequisites: Math 220 previously or concurrently and Math 205.

322. Methods of Applied Analysis I (3) UP fall-spring
Fourier series, eigenfunction expansions, Sturm-Liouville problems, Fourier integrals and their application to partial differential equations; special functions. Emphasis is on a wide variety of formal applications rather than logical development. Prerequisite: Math 205 or consent of the department chairman.

323. Methods of Applied Analysis II (3) UP spring
Green's functions; integral equations; variational methods; asymptotic expansions, method of saddle points; calculus of vector fields, exterior differential calculus. Prerequisite: Math 322.

327. Groups and Rings (3) UP fall
An intensive study of the concepts of group theory including the Sylow theorems, and of ring theory including unique factorization domains and polynomial rings.

332. Numerical Analysis (3) UP spring
Advanced quadrature methods, multistep methods for ordinary differential equations, and introduction to numerical methods for partial differential equations. Prerequisite: Math 230.

334. Mathematical Statistics (3) UP fall, odd-numbered years
Populations and random sampling; sampling distributions; theory of statistical estimation; criteria and methods of point and interval estimation; theory of testing statistical hypothesis; analysis of variance; nonparametric methods. Prerequisite: Math 309 or consent of the department chairman. Ghosh

336. Life Contingencies (3) UP spring, odd-numbered years
Selected topics from single-life functions (continued from Math 235), multi-life functions, and multidecrement functions. Relevant to Part IV of the examination offered by the Society of Actuaries. Prerequisites: Math 230 and Math 235, or consent of the department chairman.

342. Number Theory (3) UP
A survey of elementary and nonelementary algebraic and analytic methods in the theory of numbers. Includes the Euclidean algorithm, Diophantine equations, congruences, quadratic residues, primitive roots, number-theoretic functions as well as one or more of the following topics: distribution of primes, Pell's equation, Fermat's conjecture, partitions. Prerequisite: Math 219 or consent of the department chairman. Queen

350. Special Topics (3) UP
A course covering special topics not sufficiently covered in general courses. Prerequisite: consent of the department chairman. May be repeated for credit.

365. Programming Techniques (3) UP fall
Basic ideas of structured programming and data structures. Application to recognition techniques, recursion, sorting and searching, symbolic and combinatorial processing. The computer language Pascal. Numerous programming assignments to be run on the university computer. Prior programming experience helpful but not required. Gulden

371. Readings (3) UP
The study of a topic in mathematics under appropriate supervision; designed for the individual student who has studied extensively and whose interests lie in areas not covered in the listed courses. Prerequisite: consent of the department chairman. May be repeated for credit.

374. Statistical Project (3)
Supervised field project or independent reading. Prerequisite: consent of the department chairman.

381. Probability and Statistics (3)
Combinatorial problems, theory of probability, various frequency distributions, standard deviation, sampling, correlation. Prerequisite: open to secondary school teachers who present at least eighteen hours of undergraduate mathematics.

382. Algebra (3)
Fundamentals of algebra, axiomatic method, set theory, notions of group, ring, integral domain, and field. Prerequisite: open to secondary school teachers who present at least eighteen hours of undergraduate mathematics.

385. Higher Geometry I (3)
Logical systems, postulates, synthetic projective geometry, analytic projective geometry, affine, euclidean and non-euclidean geometry. Prerequisite: same as Math 381.

387. Intermediate Analysis (3)
The real number system, functions, limits, continuity, derivative, law of the mean, Taylor's formula, definite integral. Prerequisite: open only to secondary school teachers of mathematics who present at least eighteen semester hours of undergraduate mathematics including a course in analysis.

For Graduates—Mathematical Program

The department of mathematics offers a graduate in mathematics leading to the doctor of philosophy degree. The first of these degrees was awarded in 1939. In the fall of 1978 there were approximately fifty graduate students of mathematics, of whom about twenty-five were engaged in writing doctor of philosophy theses. The master of science degree in mathematics may be taken as a final degree or as an incidental step on the road to a doctor of philosophy degree.

To begin graduate work in mathematics, a student presents evidence of adequate study of mathematics as an undergraduate. The program should have included at least a year of advanced calculus, a semester of linear algebra, and a semester on groups, rings, and fields.

The program for the master of science degree will ordinarily include Math 307, 308, 316, 327, 401, 423 and 428. A student with unusually strong background, or specialized interests, may be permitted to make substitutions.

The master of science degree requires either a thesis or a comprehensive examination at the discretion of the department chairman. The same examination is used as the comprehensive examination for the master of science and the qualifying examination for the doctor of philosophy degree. Thus it is usually required for the master of science degree for those students who plan to continue to the doctor of philosophy. A syllabus for the examination is available.

The plan of work for the doctor of philosophy degree will ordinarily include courses in algebra, analysis, geometry, and topology at the 400 level and several courses including seminars in the field in which the dissertation is to be written. The department accepts candidates for the doctor of philosophy who desire to specialize in and to write a dissertation on some aspect of any of the following areas of advanced work: analysis with emphasis on pure mathematics or applied mathematics, algebra, functional analysis, differential geometry, mathematical logic, probability, statistics, and topology.

One may refer to the description of the Center for the Application of Mathematics, Section IV.

For Graduates—Computer Science Program

With the cooperation of several other departments, the department of mathematics offers a program leading to the degree of master of science in computer science.

To begin work in this program, the student must have some skill in programming in a computer language such as Fortran, Algol, Basic, APL, Pascal, or Wizard, and some familiarity with the concepts of machine or assembly languages. (Math 105 can be taken, without graduate credit, to remedy deficiency in these areas.) The student also presents at least two years of college mathematics.

The program includes the following three core courses, except as competence in the respective areas results from past courses, experience, or is demonstrated otherwise:

CIS 317	Analytical Methods for Information Sciences (3)
CIS 362	Computer Languages (3)
IE 310	File Structure and Processing (3)

The student's program is developed in consultation with a departmental adviser, and approved by an interdepartmental committee.

Further information can be found in a brochure available from the department.

Courses for Graduates

401. Real Analysis I (3) fall
Lebesgue measure and integration; differentiation; LP spaces.

402. Real Analysis II (3) spring
Continuation of Math 401. Topics such as general measure and integration theory, Radon-Nikodym theorem, Banach and Hilbert spaces, and Fourier analysis. Prerequisite: Math 401.

404. Mathematical Logic (3) spring, odd-numbered years
Topics in quantification theory relevant to formalized theories, recursive functions, Godel's incompleteness theorem; algorithms and computability. Cohen, Hailperin

405. Partial Differential Equations (3) fall
Classification and transformation of equations; theory of characteristics; initial and boundary value problems; Cauchy's problem for hyperbolic equations; Dirichlet's problem for elliptic equations; potential theory; Green's function; harmonic and subharmonic functions; difference equations; applications to equations of physics. Prerequisite: Math 220.

406. Partial Differential Equations (3) spring
Continuation of Math 405. Prerequisite: Math 405.

409. Mathematics Seminar (1-6) fall
An intensive study of some field of mathematics not offered in another course. Prerequisite: consent of the department chairman.

410. Mathematics Seminar (1-6) spring
Continuation of the field of study in Math 409 or the intensive study of a different field. Prerequisite: consent of the chairman.

416. Complex Function Theory (3) fall
Continuation of Math 316. Prerequisite: Math 316 or consent of the department chairman.

419. Linear Operators in Hilbert Space (3) fall
Algebra and calculus of bounded and unbounded operators on Hilbert space. Spectral analysis of self-adjoint, normal, and unitary operators. Interplay between operator theory and classical function theory emphasized. Prerequisites: Math 220, and Math 208 or 316. Trutt

423. Differential Geometry I (3) fall
The differential geometry of curves and surfaces in Euclidean space, including problems in the large. Hsiung

424.Differential Geometry II (3) spring
Multilinear algebra; differentiable manifolds; tensor bundles; exterior differential forms; theorems of Stokes and Frobenius; imbedding theorem; affine connections; holonomy groups; Riemannian manifolds. Prerequisites: Math 423 and 308. Hsiung

425. Differential Geometry III (3) fall
Continuation of Math 424. Curvature tensor; manifolds of constant curvature; Gauss-Bonnet formula; completeness; harmonic forms; curvature and homology; infinitesimal transformations; conjugate points and Morse index theorem; Lie groups and Lie algebras. Prerequisite: Math 424. Hsiung

428. Fields and Modules (3) spring
Field theory, including an introduction to Galois Theory; the theory of modules, including tensor products and classical algebras. Prerequisite: Math 327.

431. Calculus of Variations (3)
Fundamental existence theorems; necessary conditions and sufficient conditions for relative minima of single integrals; the index theorem; application to boundary value problems. Prerequisite: Math 401. McAllister

435. Functional Analysis I (3) fall
Linear topological spaces; local convexity; function spaces; inductive and weak topologies; duality, separation and extension theorems; the open mapping and uniform boundedness principles; Banach algebras; applications to classical analysis. Prerequisite: Math 307. Wilansky

436. Functional Analysis II (3) spring
Continuation of Math 435. Prerequisite: Math 435. Wilansky

443. General Topology II (3) spring
A continuation of Math 307, with such topics as filters and nets, topological products, local compactness, paracompactness, metrizability, uniformity, function spaces, dimension theory. Prerequisite: Math 307.

444. Algebraic Topology II (3) fall
Continuation of Math 308. Cohomology theory, products, duality. Prerequisite: Math 308.

445. Algebraic Topology III (3) spring
Homotopy theory, obstruction theory, spectral sequences. Prerequisite: Math 444.

449. Advanced Topics in Algebra (3)
An intensive study of some topics in algebra with emphasis on recent developments. May be repeated for credit. Prerequisite: consent of the department chairman.

453. Function Theory (3)
The development of one or more topics in function theory, such as analytic continuation, maximum modulus principle, conformal representation, Taylor series analysis, integral functions, Dirichlet series, functions of several complex variables. Prerequisite: Math 416.

455. Algebraic Number Theory (3)
Ideal theory, Diophantine equations, theory of locally compact fields, p-adic numbers, and cyclotomic fields. Prerequisites: Math 327 and 316, or consent of department chairman. Queen

456. Algebraic Number Theory (3)
Continuation of Math 455, with emphasis on class field theory and analytic number theory. Prerequisite: Math 455. Queen

461. Mathematical Statistics (3)
An intensive study of one or more topics not sufficiently covered in Math 334, such as theory of statistical tests, statistical estimation, regression and analysis of variance, nonparametric methods, stochastic approximation, decision theory. Prerequisites: Math 334 and 401. Ghosh

463. Probability Theory (3)
An intensive study of one or more topics not sufficiently covered in Math 309 or 310, such as limit theorems, Markov processes, ergodic theorems, martingales, time series, stochastic integrals, potential theory. Prerequisites: Math 310 and 401. Eisenberg

464. Mathematical Logic (3) spring, even-numbered years
Selected topics not dealt with in Math 404. With consent of department chairman, may be repeated for credit. Cohen

466. Advanced Programming Techniques (3) spring
Continuation of Math 365. Deeper study of structured programming, data structures, backtracking, recursion. Applications of basic concepts of automata theory and formal language theory. Fundamental principles of "large program" design. Several major programming assignments using Pascal. Prerequisite: Math 365 or consent of the department chairman. Gulden

471. Homological Algebra (3)
Modules, tensor products, categories and functors; homology functors, projective and injective modules. Prerequisite: Math 428.

472. Finite Groups (3)
An intensive study of the structure of finite groups and their automorphisms. Prerequisite: Math 428.

Astronomy

Professor. George E. McCluskey, Ph.D.

1. The Solar System (3) fall
Survey of our knowledge of the solar system. Apollo lunar missions. Mariner missions to Mercury, Venus and Mars. Viking missions to Mars. Missions to Jupiter and Saturn.

2. Stellar Astronomy (3) spring
Survey of our knowledge of stars and stellar systems. Observation and theory of pulsars, quasars, X-ray sources, gamma-ray sources, neutron stars and black holes.

211. Stellar Structure and Evolution (3) fall, even-numbered years
Physical processes in stellar interiors. Theory of stellar evolution and interpretation of observations. Binary star evolution. Theory of novae and supernovae. Prerequisites: Math 23 or 32 or 44, previously or concurrently, and Phys 21.

221. Stellar Atmospheres (3) fall, odd-numbered years
Observation and theory of stellar spectra. Model atmospheres and chemical abundances. Extended atmospheres, stellar winds and mass loss. Theory of gaseous nebulae. Prerequisites: Math 23 or 32 or 44, previously or concurrently, and Phys 21.

232. High Energy Astrophysics (3) spring, odd-numbered years
Observation and theory of X-ray and gamma-ray sources, quasars, pulsars, radio galaxies, neutron stars, black holes. Results from ultraviolet, X-ray and gamma-ray satellites. Prerequisites: Math 23 or 32 or 44, previously or concurrently and Phys 21.

242. Relativity and Cosmology (3) spring, even-numbered years
Special and general relativity. Schwarzschild and Kerr black holes. Supermassive stars. Relativistic theories of the origin and evolution of the universe. Prerequisites: Math 23 or 32 or 44, previously or concurrently, and Phys 21.

Computing and Information Science

Professors. Samuel L. Gulden, M.A.; *head*, division of computing and information science; Edward F. Assmus Jr., Ph.D.; Robert F. Barnes, Ph.D., Donald J. Hillman, M. Litt., director, Center for Information and Computer Science; John J. O'Connor, Ph.D.; Murray Schechter, Ph.D.
Associate professors. Andrew J. Kasarda, Ph.D.; Gerhard Rayna, Ph.D.
Assistant professor. Paul E. Cohen, Ph.D.

The technologies of computing and information management have created powerful forces for change in all aspects of human functioning. The discipline of computing and information science has arisen with the purposes of studying, applying and controlling these important new tools. These are now fundamental in science, industry and business. Computing and information science in its relation with mathematics, linguistics and communication also reaches beyond technology into much wider areas of intellectual and social concern.

In order to prepare those who desire to enter this discipline, the division offers a major program leading to a bachelor of science in computing and information science. The program provides a computing science option and information science option, and consists of the following three parts:
A. The common introductory courses for both the computing science and information science options
B. The computing science option
C. The information science option
The full computing and information science program consists of either A plus B or A plus C.

A Introductory courses (39 credit hours)
1. a group of basic mathematics and computing courses (21)
2. a group of more advanced mathematics courses (12)
3. a group of more advanced computing courses (6)

B Computing Science Option
1. computing science courses (27)
2. professional electives (24)
3. distribution (18 humanities, 12 social science) (30)

Total credits required for the computing science option 120

C Information Science Option
1. behavioral foundations (12)
2. information science and technology (18)
3. professional electives (21)
4. distribution (18 humanities, 12 social science) (30)

Credits totaling 120 hours are required for the information science option. The structure of these groups is as follows:

A-1 *Introductory Courses (21)*

Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry and Calculus II (4)
Math 23	Analytic Geometry and Calculus III (4)
Math 61	Logical Methods (3)
CIS 11	Introduction to Structured Programming (3)
CIS 12	Programming Techniques (3)

A-2 *Mathematics courses* (12)

Math 205	Linear Methods (3)
Math 231	Probability and Statistics (3)
CIS 317	Analytical Methods for Information Sciences (3)
CIS 318	Computing Algebra (3)

A-3 *Computing courses* (6)

EE 141	Switching Theory and Logic Design (3)
CIS 203	Advanced Programming (3)

Students in the information science option may replace CIS 203 with CIS 362, Programming Languages (3).

B-1 *Computing science courses* (27)

Math 230	Numerical Analysis (3)
CIS 102	Foundations of Computing Science (3)
CIS 211	Computer Organization (3)
CIS 302	Software Systems I (3)
CIS 303	Software Systems II (3)
CIS 309	Mini-Micro Processor Software Design (3)
CIS 362	Programming Languages (3)
CIS 371	Readings and Project I (3)
CIS 372	Readings and Project II (3)

B-2 *Professional electives* (24)
These courses are elected with the approval of the student's adviser. They may be chosen from any appropriate courses in the natural sciences, mathematical sciences, social sciences, computing and information sciences, and engineering sciences. These courses may be used to give an orientation to the student's course of study. For example, the student may want to elect physics and chemistry courses to prepare for the growing computer technology in energy and environmental studies. In addition, students who wish to turn to the use of the computer in business and finance might consider industrial engineering, economics, accounting and finance courses.

B-3 *Distribution* (30)
These are courses to be elected from the social sciences (12) and the humanities (18).

C-1 *Behavioral Foundations* (12)

Psych 1	Introduction to Psychology (3)
Psych 151	Elementary Quantitative Psychology (3)
Psych 307	Cognitive Psychology (3)
Electives (3)	

C-2 *Information science and technology* (18)

IE 18	Data Processing Fundamentals (3)
CIS 321	Introduction to Information Methodology (3)
CIS 374	Information Retrieval Theory (3)
IE 309	Information System Development (3)
IE 310	File Structure and Processing (3)
Electives (3)	

C-3 *Professional electives* (31)

The professional elective courses are chosen by the student, with the approval of the major adviser, to provide a specialized direction to the curriculum. These include courses in formation processing, information transfer systems, man-machine relationships, library automation, educational systems, management systems, and the like.

C-1 *Distribution* (30)

These are courses to be elected from the social sciences (12 credit hours) and the humanities (18).

Graduate Programs

On the graduate level, both master of science and doctor of philosophy programs are offered. These aim at providing practitioners in computing and information science with the strong conceptual background necessary to keep pace with rapid changes in the field. Each program provides a base of both theory and application, with emphasis on fundamentals, rather than simply on techniques.

Basic to both programs is the concept that research and instruction reinforce each other. Consequently, whenever possible, students are expected to participate in research activities.

The graduate program is based on a bachelor's degree in mathematics, computer science, information science, engineering, or physical science. Maximum advantage is taken of courses in other departments on the campus. Consequently a student's program is a combination of courses in computing and information science, together with offerings by the departments of electrical engineering, industrial engineering, mathematics, psychology, social relations, and others.

A candidate for the degree of master of science completes at least twenty-four hours of approved course work and submits a thesis or research report. Each student's schedule is chosen in consultation with the head of the division. Student schedules are planned on an individual basis to fit previous academic experience and career goals. Depending upon the candidate's background and interests, emphasis can be either in theoretical or applied directions.

A candidate for the doctor of philosophy submits a general plan to the division head at the beginning of the first year of doctoral studies. This plan must be approved by the candidate's special committee at the time of admission to candidacy.

The doctoral program in computing and information science is based on the candidate's approved plan of original and specialized research. A program of courses and seminars at the 400 level is formulated in the field in which the dissertation will be written.

11. Introduction to Structured Programming (3) UP
Algorithmic design and implementation in high-level, block-structured, procedure-oriented languages. No prior computing experience required.

12. Programming Techniques (3) UP
Continuation of CIS 11. Prerequisite: CIS 11.

13. Computer Programming for the Humanities and Social Sciences (3) fall
An introduction to computer programming with special emphasis on the requirements of language-oriented applications. Fortran will be taught for basic quantitative manipulations, and Snobol 4 for qualitative purposes. The course stresses the importance of defining and formulating problems via flow charts. No previous knowledge of computer programming is required. Hillman

14. Computer Applications in the Humanities and Social Sciences (3) spring
Applications of computers to studies in the humanities and social sciences to obtain greater rigor and sophistication. Both quantitative and qualitative applications are covered, but special attention is given to recent developments of the latter sort, since these applications are often the more significant ones. Prerequisite: CIS 13 or its equivalent. Hillman

81. Computers and Calculus (1) UP fall
Writing and testing digital computer programs to solve problems arising from the calculus. Designed for students enrolled in Math 21, 31 and 41 who are not taking another introductory course in computing. No previous knowledge of programming is assumed. Prerequisite: Math 21, 31 41, concurrently or previously.

82. Computers and Calculus (1) UP spring
A continuation of Math 81. Prerequisite: Math 81 or consent of department chairman.

102. Foundations of Computing Science (3) UP
Elementary discrete structures; algorithmic structures; introduction to machine organization, assemblers, loaders, languages. Prerequisite: CIS 11.

105. Assembly-Language Programming (3) UP fall-spring
The translation of simple mathematical and logical problems into forms permitting their solution by digital computers, with emphasis on machine-language programming of several typical types of computers. Rayna

110. Algorithmic Processes (3) UP
Abstract models of machine processes. Computability and unsolvability, generability, decidability, and acceptability as algorithmic processes. Special topics such as recursive function theory and computational complexity may be covered. Barnes

201. Computers and Language (3)
The role of computers in such activities as natural language processing, mechanical translation, speech recognition, and augmentation of human reasoning.

202. Computers and Society (3)
A general nontechnical survey of the impact of computers on modern society. Special attention is given to the use of large-scale data banks and retrieval systems, the problems of privacy and file security, and the impact of automation on everyday life.

203. Advanced Programming (3) UP
Advanced informational structures, list processing, symbolic processing, basic formal language theory, elementary parsing and interpreting algorithms, assembly language, introduction to computer organization. Prerequisite: CIS 12.

211. Computer Organization (3)
Structured organization of digital machines, virtual processors; software compatibility. Prerequisite: CIS 102 and 203.

301. Descriptive Linguistics (3) fall
Techniques for the description of the phonology, morphology, and syntax of natural languages. Special attention to transformational generative grammar. Rubenstein

302. Software Systems I (3)
Applications of formal language theory; LL(K), LR(K), and other parsing algorithms; design and implementation of compilers and interpreters. Prerequisite: CIS 203.

303. Software Systems II (3)
Assemblers, executive systems, multiprogramming, time-sharing. Concurrent tasks, deadlocks, resource sharing. Construction of a small operating system. Prerequisites: CIS 203 and 211.

309. Mini-Micro Processor Software Design (3)
Introduction to the development of software for a small computer. Prerequisite: CIS 203.

310. (Ed 320/Psych 320) Psycholinguistics (3)
Study of the experimental and observational literature on psychological processes involved in the production, comprehension and use of language by adults. Rubenstein

317. (EE 317) Analytical Methods for Information Sciences (3)
Series of topics in discrete mathematics chosen for their applicability to computer science, coding theory and information retrieval. Sets; binary relations; lattices; Boolean algebras and application to logic design; semigroups and relevance to automata; groups and application to coding; fields and relevance to circuits and codes; graphs and application to file searching. Prerequisite: senior standing or consent of department chairman. Tzeng

318. Computing Algebra (3)
Continuation of 317 Formal languages, parsing, semantics. Prerequisite: CIS 317.

320. (Psych 308) Information Processing: Human and Machine (3) alternate years
Study of the identification, storage, retrieval and use of auditory and visual inputs in decision-making contexts. Human and mechanical information processes, their similarities and differences. Rubenstein

321. Introduction to Information Methodology (3)
History, theory and structure of indexing and classification systems for the organization of information; comparative analysis of selected retrieval schemes; experimental methods for developing indexing systems and analyzing subject content.

324. (Psych 324) Life-Span Development of Information Processing Abilities (3) SS
Perception, storage, retrieval, use and communication of information as these abilities change from infancy to old age.

330. Low-Cost Personal Retrieval Systems (3) spring
Retrieval systems applicable to personal information collections gathered for study, research, hobby, or other purposes. Experimental study, each student working with his or her personal information collections. Emphasis on systems requiring no mechanical devices. Also some study of computerized systems. O'Connor

361. Automata and Formal Grammars (3)
Study of the interaction between recognition devices and generation devices for formal languages. Comparison of automata and formal grammars of differing strengths. Application to questions of computability and decidability. Barnes

362. Programming Languages (3) fall
Use, structure and implementation of several programming languages. Prerequisite: Math 105 or CIS 102 or CIS 105. Rayna

371. Readings and Project I (3)
Supervised independent work.

372. Readings and Project II (3)
Supervised independent work on a major project.

374. Information Retrieval Theory (3)
An introduction to the problems of computerized information storage and retrieval systems. Special attention is given to the logical and mathematical techniques for automatic text-processing, file generation, and inquiry negotiation.

379. Introduction to Library Organization (3) offered as required
An introduction to libraries as information organizations, including their history, function and structure. This course is intended to supply a frame of reference for those students intending to take CIS 380, Library Automation; and to provide a background for students interested in broad applications of information science to social and educational needs.

380. Library Automation (3) offered as required
A study of methods and procedures in the application of automated equipment in libraries. Special attention is given to the augmentation of acquisition, cataloging, circulation and reference functions. Prerequisite: CIS 379 or consent of the department chairman.

390. Special Topics (1-3) offered as required
An opportunity for advanced work through supervised reading and research. Prerequisite: consent of the department chairman. May be repeated for credit.

402. (Psych 448) Seminar in Psycholinguistics (3)
Selected topics in psycholinguistics examined in depth and in detail. Prerequisite: CIS 310. Rubenstein

418. Special Topics in Linguistics (3) offered as required
Selected topics in linguistics not covered in other courses. Rubenstein

422. Analysis of Information Systems (3)
The study of the organization of information systems with respect to design criteria, information acquisition and entry, information processing, classification and storage, retrieval and dissemination, feedback control and evaluation; operational requirements such as hardware, software and personnel, and system economics. Kasarda

431. Subject Document Retrieval (3)
Technique and systems for retrieval of documents in response to subject requests. Fundamental ideas, achievements to date, problems and possibilities. Topics covered include request negotiation techniques, document indexing (coordinate, relational, weighted), Boolean and weighted-term searching methods, and thesauri and classifications as aids to negotiation, indexing and searching. O'Connor

432. ALP-Aided Document Retrieval (3) spring
Subject document retrieval aided by automatic language processing (ALP). Fundamental ideas, achievements to date, problems and possibilities. Topics covered include computer and man-machine performance of the following functions: subject indexing and classification of documents, abstracting, construction of thesauri and classification of schedules, retrieval by searching natural language text of unindexed documents, and on-line negotiation of retrieval requests. Prerequisite: CIS 431 or equivalent. O'Connor

433. (EE 403) Design of Operating Systems (3)
Principles of operating systems with emphasis on hardware and software requirements and design methodologies for multiprogramming systems. Global topics include the related areas of process management, resource management, and file systems. Prerequisite: EE 315 or equivalent. Ota

442. Evaluation Models (3) offered as required
An investigation of the activities necessary to the development of formal structures for evaluating complex systems. Particular treatment is directed toward the evaluation of large information retrieval systems. Topics covered include establishment of system objectives, recognition and isolation of variables, economic aspects, empirical testing.

450. Information Network Theory (3) offered as required
Applications of graph theory to the modeling, simulation, and design of information networks. Prerequisite: CIS 374.

462. Retrieval Languages (3) alternate years
The study of formal indexing and retrieval languages, with special attention to the interaction between syntactic structure and retrieval properties. Examples are drawn from actual and experimental systems to show the effect of syntactic structure upon system capabilities. Barnes

466. Topics in the Theory of Automata and Formal Grammars (3) alternate years
Advanced study of automata-theoretic approaches to questions of computability, decidability, acceptability, and generability. May be repeated for credit. Prerequisite: CIS 361 or consent of the department chairman. Barnes

481. Thesis (3)

482. Thesis (3)

492. Special Topics in Information Science (3) offered as required
Selected topics in the information sciences not covered in other courses.

494. Information, Communication and Culture (3) fall
Human communication as a process of exchanging information, as a shaper of the culture, and their mutual interaction. Syntactics, semantics, and pragmatics as theoretical approaches to the study of communication and information.

Mechanical Engineering And Mechanics

Professors. Douglas E. Abbott, Ph.D., *chairman;* Ferdinand P. Beer, Ph.D.; Russell E. Benner, Ph.D.; Philip A. Blythe, Ph.D., Center for the Application of Mathematics (CAM); Forbes T. Brown, Sc.D.; John C. Chen, Ph.D., director, Institute of Thermo Fluids; Fazil Erdogan, Ph.D.; Ronald J. Hartranft, Ph.D.; Arturs Kalnins, Ph.D.; Edward K. Levy, Sc.D., director, Energy Research Center; Alister K. Macpherson, Ph.D.; Jerzy A. Owczarek, Ph.D.; Ronald S. Rivlin, Ph.D., Centennial university professor, director, CAM; Richard Roberts, Ph.D.; Donald O. Rockwell, Ph.D.; Eric P. Salathe, Ph.D. (CAM); Robert G. Sarubbi, Ph.D.; George C.M. Sih, Ph.D., director, Institute for Fracture and Solid Mechanics; Gerald F. Smith, Ph.D. (CAM); Eric Varley, Ph.D. (CAM); Robert P. Wei, Ph.D.
Associate professors. Peter D. Hilton, Ph.D.; Stanley H. Johnson, Ph.D.; Robert A. Lucas, Ph.D.; Charles R. Smith, Ph.D.; Theodore A. Terry, Ph.D.; Dean P. Updike, Ph.D.; J. David A. Walker, Ph.D. (CAM).
Assistant professor. Terry J. Delph, Ph.D.
Visiting assistant professors. A. Terrence Conlisk, Ph.D.; Sudhakar Neti, Ph.D.; Taner F. Ozkaynak, Ph.D.; Andreas Schachenmann, Ph.D.
Adjunct professors. Thomas E. Jackson, M.S.; Stanley J. Jakubowski, B.S.M.E., B.S.E.E.; Ramu K. Sundaram, Ph.D.
Research engineer. E. Jack London, B.S.M.E.

Engineering is a creative profession aimed at satisfying needs of society through the combination of material, human and economic resources. Mechanical engineering is one of the broadest of the engineering professions, dealing generally with systems for energy conversion, material transport, and the control of motions and forces.

Individual mechanical engineers may choose from among many different activities in their careers, according to their interests and the changing needs of society. Some concentrate on the conversion of thermal, nuclear, solar, chemical and electrical energy, or on the problems of air, water and noise pollution. Some concentrate on the design of mechanical systems used in transportation, production or health care, or by individual consumers. Some will be working, a decade from now, in fields which do not yet exist. Most will be engaged with concepts involving all four dimensions, space and time.

The curriculum leading toward the bachelor of science in mechanical engineering combines a broad base in mathematics, physical sciences and the engineering sciences (mechanics of solids, materials, dynamics and fluid, thermal and electrical sciences) with exposure to laboratory, the design process, computer techniques, and specific applications fields. Much of the latter occurs in five or more courses elected toward the end of the program from a variety of offerings, which are identified by 300-level course designations. Courses in mechanical engineering and mechanics are equally available.

A program also is offered leading toward the bachelor of science in engineering mechanics. This program requires additional courses in mathematics, solid mechanics and dynamics and less required emphasis on thermodynamics and mechanical design. It is especially appropriate for those most interested in the analysis of the behavior of engineering structures.

Graduates in either degree are equipped for work in engineering or research and development, and in government service or industry. Those with ability and interest have suitable backgrounds for further studies at the graduate level.

Because of the flexibility of the curriculum, candidates for either degree may combine the study of mechanical engineering or engineering mechanics with that of other fields, such as chemical engineering, materials engineering, and biology, into interdisciplinary programs which will prepare them for further work in the areas of nuclear engineering, energy conversion and conservation, environmental engineering, materials engineering, or biomechanics.

freshman year (see page 43)

sophomore year, first semester (17 credit hours)

Math 23	Analytical Geometry and Calculus III (4)
Mech 1	Statics (3)
Phys 21,22	Introductory Physics II and Laboratory (5)
ME 12	Engineering Drawing and Descriptive Geometry (2)
	General Studies requirement (3)

sophomore year, second semester (17 credit hours)

Math 205	Linear Methods (3)
ME 104	Thermodynamics I (3)
Mech 11	Mechanics of Materials (3)
ME 21	ME Laboratory I (1)
Met 63	Engineering Materials (3) *or*
Met 91	Elements of Materials Science
Eco 1	Economics (4)

junior year, first semester (17 credit hours)

Mech 102	Dynamics (3)
ME 105	Thermodynamics II *or* approved elective (3)
ME 231	Fluid Mechanics (3)
EE 160	Introduction to Electrical Engineering (4)
EE 162	Electrical Laboratory (1)
	General Studies requirement (3)

junior year, second semester (14-17 credits)

ME 101	Mechanical Engineering Design (1)
ME 151	Mechanical Elements *or* approved elective (3)
Mech 203	Advanced Strength of Materials (3)
CE 123	Fluid Mechanics Laboratory (1)
ME 242	Mechanical Vibrations (3)
Math 208	Complex Variables *or*
Math 231	Probability and Statistics (3)
	elective (0-3)*

*Please refer to description of normal program, page 43.

Note: In the junior year, candidates for the bachelor of science in mechanical engineering take ME 105 and ME 151; candidates for the bachelor of science in engineering mechanics take Math 208.

The approved electives must represent a coherent group of approved courses such as 200-and 300-level courses in mechanical engineering and mechanics, as well as mathematics, physics, chemistry and a limited number of other fields. For candidates for the bachelor of science in mechanical engineering, six hours of approved electives are required in mechanical engineering and at least six more in mechanical engineering or mechanics.

For candidates for the bachelor of science in engineering mechanics, the following courses are required: Mech 302, Advanced Dynamics; Mech 305, Advanced Mechanics of Materials; Mech 307, Mechanics of Continua; and Math 322, Methods of Applied Analysis I.

Undergraduate Courses in Mechanical Engineering

12. Engineering Drawing and Descriptive Geometry (2) fall
Engineering drawing, including sketching, machine operations, dimensioning, and tolerancing; detail and assembly drawings. Elements of descriptive geometry.

21. Mechanical Engineering Laboratory I (1) fall, spring
Lectures and laboratory exercises relating to engineering

laboratory technique and procedures. Includes planning, execution and analysis of tests and writing of reports. Application to measurement of mechanical properties of materials. Prerequisite: Mech 11, previously or concurrently.

100. Industrial Employment (0)
Usually following the junior year, students in the mechanical engineering or engineering mechanics curriculum are expected to do a minimum of eight weeks of practical work, preferably in the field they plan to follow after graduation. A report is required. Prerequisite: sophomore standing.

101. Mechanical Engineering Design I (1) spring
Objectives and specifications are developed for design projects to be carried out in the following semester. Alternative design concepts are proposed and oral and written reports of feasibility studies are presented.

102. Mechanical Engineering Design II (2) fall
A continuation of ME 101 in which groups are organized to do preliminary design on a previously defined project. Program organization techniques are used and laboratory testing and data acquisition are carried out as needed to promote design development. Prototypes are constructed and tested, when practical. Prerequisites: ME 101, Mech 11, ME 104.

104. Thermodynamics I (3) fall, spring
Basic concepts and principles of thermodynamics with emphasis on simple compressible substances. First and second law development, energy equations, reversibility, entropy and probability. Properties of pure substances and thermodynamic cycles. Prerequisites: Math 23, Phys 11.

105. Thermodynamics II (3) fall, spring
Equations of state, non-reacting and reacting mixtures, combustion, equilibrium of mixtures both reacting and nonreacting, statistical thermodynamic concepts. Compressible flow. Prerequisite: ME 104.

108. Laboratory I (2) fall
Lectures and laboratory exercises relating to various phases of engineering laboratory technique and procedures. Includes planning, execution, and analysis of tests and writing of reports. Prerequisite: ME 105.

109. Laboratory II (2) spring
Continuation of ME 108 with emphasis on project investigations.

110. Thesis (1-3) fall-spring
Candidates for the degree of bachelor of science in mechanical engineering may, with the approval of the director of the curriculum, undertake a thesis as a portion of the work during the senior year.

151. Mechanical Elements (3) fall-spring
Methods for the analysis and design of machine elements such as springs, gears, clutches, brakes, and bearings. Motion analysis of cams and selected mechanisms. Projects requiring the design of simple mechanisms or mechanical sub-assemblies. Prerequisites: Mech 11, ME 12 and Mech 102.

166. Procedures for Mechanical Design (2) spring
General design procedures, motion analysis, force analysis, static, repeated and impact types of loading, modes of failure theories. Applications to the design of typical machine elements. Prerequisite: Mech 11.

For Advanced Undergraduates and Graduate Students

231. Fluid Mechanics (3) fall-spring
Fundamental concepts. Physical similarity. Kinematics of fluid flow. Equations of flow in integral form. Equations of flow of perfect fluids. Plane irrotational flow of incompressible fluids. Navier-Stokes equation; hydrodynamic stability; turbulence. Two-dimensional boundary layers in incompressible flows; separation of flow; wakes; drag. Effects of compressibility on fluid flow. Hydraulic treatment of losses in flows in ducts. Flows with free surface. Basic measurements techniques. Prerequisite: Math 205.

242. Mechanical Vibrations (3) fall-spring
Physical modeling of vibrating systems. Linearization. Free and forced single and multiple degree of freedom systems. Simple continuous systems. Engineering applications. Prerequisites: Mech 102 or 103, Math 205.

310. Projects (1-6) fall-spring
Project work on any aspect of engineering, performed either individually or as a member of a team made up of students possibly from other disciplines. Direction of the projects may be provided by faculty from several departments and could include interaction with outside consultants and local communities and industries. Prerequisite: consent of the department chairman.

312. Synthesis of Mechanisms (3) spring
Geometry and constrained plane motion with application to linkage design. Type and number synthesis. Comparison of motion analysis by graphical, analytical and computer techniques. Euler-Savary and related curvature techniques as applied to cam, gear and linkage systems. Introduction to the analysis of space mechanisms. Prerequisites: Math 205, Mech 102. Terry

320. Thermodynamics III (3) fall
Advanced treatment of thermodynamic laws both for single element and mixtures. Phase equilibrium. Ideal solutions, chemical equilibrium. Thermodynamic cycle analysis, real fluid properties, availability. Prerequisite: ME 104. Macpherson

321. Introduction to Heat Transfer (3) fall-spring
Analytical, numerical, and analog solutions to steady and transient, one- and two-dimensional conduction problems; thermal radiation, free and forced convection of laminar and turbulent flows inside cylindrical tubes and over external surfaces; thermal design of heat exchangers. Prerequisites: ME 104, ME 231. Chen, Levy

322. Gas Dynamics (3) spring
Equations of flow of compressible fluids. Thermodynamic properties of gases. Shock waves. One-dimensional steady flow through ducts with variable cross-sectional area, flows with viscous friction and heat addition. Prerequisites: ME 231, ME 104, Math 205. Owczarek, Rockwell

324. Aerospace Propulsion Systems (3) spring
Cycle analysis of air-breathing engines. Optimum configurations for different flight regimes. Chemical and nuclear rocket engines. Component design. Prerequisite: ME 105. Jackson

325. Vehicular Propulsion Systems (3) fall
Thermal analysis of internal combustion engines for vehicular propulsion. Component design. Unconventional propulsion systems. Applications to current problems in ground transportation. Prerequisite: ME 105. Jackson

327. Modern Coal Technology (3) fall
Application of the thermal-fluid sciences in the analysis and critical assessment of coal combustion and conversion processes. Properties of coal; environmental constraints; precombustion cleaning; fluidized bed combustion; flue gas desulfurization; gasification; liquefaction; power cycle analysis; energy economics. Prerequisite: ME 105 or senior standing. Levy

331. Fluid Mechanics (3) fall
Kinematics of fluid flow. Conservation equations for inviscid and viscous flows; integral forms of equations. Two-dimensional potential flow theory of incompressible fluids with applications. Boundary layers. Introduction to free shear layer and boundary layer stability and structure of turbulence. Transition from laminar to turbulent boundary layers. Separation of flow. Steady and unsteady stall. Secondary flows. Flow of non-Newtonian fluids. Hydrodynamic lubrication. Measurement techniques. Prerequisite: ME 231 or equivalent. Owczarek, Rockwell, C. Smith

340. Advanced Mechanical Engineering Design (3) spring
Optimum design of mechanical components and systems. Parameter optimization by the theory of maxima and minima, geometric programming and optimum seeking methods. Automated design. Probabilistic approaches to design. Prerequisite: Math 231. Benner

341. Mechanical Systems (3) fall
Advanced topics in mechanical systems design. Friction, wear and lubrication with applications to friction drives, journal and rolling-element bearings. Shock and vibration control in machine elements such as springs, gears and rotating discs. Rotor-bearing system dynamics. Balancing of rotating and reciprocating machines. Prerequisites: ME 151, Mech 203 and ME 242. Benner

342. Dynamics of Engineering Systems (3) fall
Dynamic analysis of mechanical, electromechanical, fluid and thermal engineering systems with emphasis on the modeling process. Survey of numerical methods with emphasis on dynamic simulation and computer practice. Prerequisite: ME 242. Johnson.

343. Control Systems (3) fall-spring
Linear analysis of mechanical, hydraulic, pneumatic, thermal and electrical feedback control systems. Transient and frequency response, root locus, stability criteria and compensation techniques. Prerequisites: Math 205 and ME 242. Brown, Johnson

350. Special Topics (1-4)
A study of some field of mechanical engineering not covered in the general courses. Prerequisite: consent of the chairman.

360. (ChE 360) Nuclear Reactor Engineering (3) fall-spring
A consideration of the engineering problems in nuclear reactor design and operation. Topics include reactor fuels and materials, thermal aspects, instrumentation and control problems, radiation protection and shielding, fuel processing, and reactor design. Prerequisite: senior standing in engineering or physical science. Chen, Clump, Neti

Graduate Programs in Mechanical Engineering

The department offers programs of study leading to the degrees of master of science, master of engineering and doctor of philosophy in mechanical engineering.

A student whose background is different from that required in the undergraduate mechanical engineering curriculm or who has a particular deficiency may be required to present a larger number of credits than the minimum indicated for graduation.

Subject to approval, courses from other engineering curricula, such as mechanics, chemical engineering, and metallurgy and materials engineering, may be included in the major.

A student who plans to work for the doctorate should submit a general plan to the department chairman during the first year and arrange for the qualifying examinations.

Master of Science

The master of science degree is often considered the appropriate background for one who wants to work on the more technical creative aspects of mechanical engineering. As such it emphasizes a broad extension of fundamentals rather than specialization in one field, although there is considerable latitude in the choice of courses. The required six-credit-hour thesis for the master of science likely concentrates in one research area, but can be viewed primarily as an in-depth project experience under the guidance of an expert.

Master of Engineering

The program leading to the master of engineering degree aims primarily at advanced design methods and creative design projects. Six credit hours of MR 460, Engineering Project, are required in lieu of a thesis. A wide range of interdisciplinary course offerings permits construction of a program including several of the following areas: mechanical systems, reliability engineering, probabilistic approaches to design, mechanism synthesis, stress analysis, digital and analog computer-aided design, and optimum design.

Doctor of Philosophy

Candidacy for the doctor of philosophy follows passage of a qualifying examination which also emphasizes a broad grasp of fundamentals. In most cases, largely through the dissertation, the candidate emphasizes one or more specialized fields and engages in extensive research in collaboration with one or more faculty members. Basic and applied research is ongoing in a variety of fields including fluid and solid mechanics, heat and mass transfer, thermodynamics, energy conversion, mechanical design and system dynamics and control.

Equipment available for research includes mini- and microcomputers with A/D converters, high-speed TV and photographic systems, several channels of hot wire/film anemometry, a six-inch interferometer, a two-phase boiling loop, several water and wind tunnels, fluidized bed test facilities, a fluidized combustor, gas-dynamic test facilities, a heat-pump test facility, a corrosion fatigue test facility, a variety of electrodynamics and servo-controlled hydraulic testing machines, a 1200-pound shaker table, a photo-elastic bench, and a laser.

Some of the recent activities of the staff are listed below.

Thermofluids. Structure of turbulent boundary layers; unsteady viscous flows; viscous effects in turbomachinery; centrifugal (rotating) fluidized beds; new instrumentation for liquid film dynamics; inverse annular two-phase flows; design of a high-speed liquid lithium target; unsteady-state flow in diffusers; laminar-turbulent transition behind a barrier; self-sustained oscillations of separated flows; flow-induced vibrations; fluidic operational amplifier; fluid transients in tubes; fluid-jet dynamics; laser doppler velocimetry; fluidized-bed exchangers; multi-component boiling; convection in post-critical heat-flux boiling; thermal hydraulics of liquid metal boiling; Raman spectra applied to temperatures in two-phase flow; measurements in gas flows following shock waves; optimization of designs of air separation plants; cycle analysis for fluidized-bed combustors; cycle analysis applied to coal gasifiers and powercycles; breeder-reactor safety; light-water reactor safety; hydraulics-control-system optimization; dynamic simulation and control of large systems; control optimization of heat pumps; finite element computations relative to turbulent flows; flutter of blades in axial-flow turbomachinery.

System dynamics and control. Modeling and advanced simulation of dynamic systems including vehicles, chemical processes, aeroelastic structures and heat-pump systems; methods of experimental identification and analysis of distributed-parameter systems including unsteady turbulent flow in tubes and diffusers; energy methods and bondgraphs in modeling; stochastic optimal and other modern control techniques applied to vehicles and electrohydraulic servomechanisms.

420. Advanced Thermodynamics (3) fall 1979, and spring 1981.
Critical review of thermodynamics systems. Criteria for equilibrium. Applications to electromagnetic systems. Statistical thermodynamics. Irreversible thermodynamics. Thermoelectric phenomena. Macpherson

421. Topics in Thermodynamics (3)
Emphasis on theoretical and experimental treatment of combustion processes including dissociation, flame temperature calculations, diffusion flames, stability and propagation; related problems in compressible flow involving one-dimensional, oblique shock waves and detonation waves. Methods of measurement and instrumentation.

424. Turbulent Flow (3) spring, 1980
Stability of laminar flow; transition to turbulence. Navier-Stokes equations with turbulence. Bounded turbulent shear flows; free shear flows; statistical description of turbulence. Prerequisite: ME 331. Abbott, Rockwell

426. Radiative and Conductive Heat Transfer (3) fall, 1980
Principles of radiative transfer; thermal-radiative properties of diffuse and specular surfaces: radiative exchange between bodies; radiative transport through absorbing, emitting and scattering media. Advanced topics in steady-state and transient conduction; analytical and numerical solutions; problems of combined conductive and radiative heat transfer. Prerequisite: ME 321 or ChE 421. J. Chen

427. (ChE 427) Multiphase Heat Transfer (3) spring, 1980
Heat transfer and fluid dynamics of multiphase systems. Subcooled, nucleate, and film boiling; bubble nucleation; dynamics of bubble growth and collapse; vapor-liquid cocurrent flow regimes; two-phase pressure drop and momentum exchange, low instabilities; convective-flow boiling; simultaneous heat and mass transfer. Prerequisite: ME321 or ChE 421. Chen

428. Boundary Layers and Convective Heat Transfer (3) fall, 1979 and spring, 1981
Navier-Stokes and energy equations, laminar boundary layer theory, analysis of friction drag, heat transfer and separation. Transition from laminar to turbulent flow. Turbulent boundary layer theory, Prandtl mixing length, turbulent friction drag, and heat transfer. Integral methods. Flow in ducts, wakes and jets. Natural convection heat transfer. Prerequisite: ME 331 or ME 321. Levy, Owczarek, Rockwell

431. Advanced Gas Dynamics (3) fall, 1980
Method of characteristics. Unsteady continuous flow. Unsteady flows with discontinuities. Shock tubes. Detonation waves. Two-dimensional and axisymmetric supersonic flows. Momentum and energy equation of compressible viscous fluids. Prerequisite: ME 322. Owczarek, Rockwell

432. Topics in Gas Dynamics (3)
The equilibrium thermodynamic properties of a dissociating mixture of gases. Equilibrium flow of dissociating gases. Vibrational and chemical nonequilibrium. Criteria for thermodynamic equilibrium of gas flow. Chemical kinetics of gaseous reactions. Equations of flow of a reacting gas mixture. Nonequilibrium flows. Application to design of ram-jets and rocket nozzles and of reentry vehicles. Prerequisites: ME 320 and ME 322.

439. Fluid Mechanics of Turbo-machinery (3)
The Euler equation. One-dimensional analysis of turbomachinery. Performance characteristics. Limitations on performance imposed by real fluid effects. Cascade flow. Two-and three-dimensional flow. Surge and stall. Owczarek

442. Analytical Methods in Engineering I (3) fall
Analytical methods of solution for discrete and continous engineering systems. Theoretical, numerical and approximate methods of solution applied to equilibrium, characteristic value and propagation types of engineering problems. Lucas, Walker

443. Analytical Methods in Engineering II (3) spring
Continuation of ME 442.

444. Experimental Stress Analysis in Design (3)
Applications of experimental stress analysis to mechanical design problems. Roberts, Wei

446. Mechanical Reliability (3) spring, 1980
Design of mechanical engineering systems to reliability specifications. Probabilistic failure models for mechanical components. Methods for the analysis and improvement of system reliability. Effect of component tolerance and parameter variation on system failure. Reliability testing. Prerequisite: Math 231 or Math 309. Benner, Sarubbi

448. (EE 448) Optimal Control and Design Theory (3) fall, 1979, and spring 1981
Parameter optimization in design and optimal open-loop and feedback control via the extrema of unconstrained and constrained functions and functionals (calculus of variations). Matrix and state space formulation, Lagrange multipliers, Pontryagin maximum principle, Hamilton-Jacobi theory, matrix Ricatti equations, sensitivity analysis. Survey of observability and controllability, dynamic programming, and Kalman filter. Intended for engineers with a variety of backgrounds. Prerequisite: ME 340 or 343 or EE 212 or ChE 286. Brown, Johnson

450. Special Topics (3)
An intensive study of some field of mechanical engineering not covered in more general courses.

451. Seminar (1-3)
Critical discussion of recent advances in mechanical engineering.

458. Modeling of Dynamic Systems (3) fall, 1980
Modeling of complex linear and nonlinear energetic dynamic engineering systems. Emphasis on subdivision into multiport elements and representation by the bondgraph language using direct, energetic, and experimental methods. Field lumping. Analytical and graphical reductions. Analog, digital and hybrid simulation. Examples including mechanisms, electromechanical transducers, electric and fluid circuits, and thermal systems. Prerequisite: ME 342 or ME 343 or EE 212. Brown, Johnson

459. Advanced Systems Control (3)
Stochastic signals in estimation and optimal feedback control. Numerical techniques for nonlinear two-point boundary value problem. Stability and design criteria for nonlinear systems. Prerequisite: ME 448 (EE 448). Brown, Johnson

460. Engineering Project (1-6)
Project work on some aspect of mechanical engineering in an area of student and faculty interest. Selection and direction of the project could involve interaction with local communities or industries. Prerequisite: consent of the department chairman.

Undergraduate Courses In Mechanics

1. Statics (3) fall-spring
Composition and resolution of forces; equivalent force systems; equilibrium of particles and rigid bodies; centroids and centers of gravity; analysis of simple structures; internal forces in beams; friction; moments and products of inertia; method of virtual work. Prerequisites: Math 22 and Phys 11.

11. Mechanics of Materials (3) fall-spring
Strength and elasticity of materials; theory of stresses and strains; deflection of beams and shafts; torsion; buckling of struts. Prerequisites: Mech 1; Math 23, previously or concurrently.

102. Dynamics (3) fall-spring
Kinematics and kinetics of particles and rigid bodies in two and three dimensions; relative motion; work and energy; impulse and momentum. Prerequisites: Mech 1 and Math 23.

103. Principles of Mechanics (4) spring
Composition and resolution of forces; equivalent force systems; equilibrium of particles and rigid bodies; friction. Kinematics and kinetics of particles and rigid bodies; relative motion; work and energy; impulse and momentum. Prerequisites: Math 23 and Phys 11.

104. Dynamics and Vibrations (3) spring
Kinematics and kinetics of particles and rigid bodies in two dimensions; relative motion; work and energy; impulse and momentum. Introduction to vibrations. For civil engineering students. Prerequisites: Mech 1 and Math 23.

For Advanced Undergraduates and Graduate Students

203. Advanced Strength of Materials (3) fall-spring
Elementary consideration of stress and strain at a point. Stress-strain relations in two dimensions. Basic equations of motion. Classical theories of failures. Analysis of simple continuum systems with applications to materials behavior phenomena. Prerequisites: Mech 11 and Math 205.

302. Advanced Dynamics (3) spring
Fundamental dynamical theorems and their application to the study of the motion of particles and rigid bodies, with particular emphasis on three-dimensional motion. Use of generalized coordinates; Lagrange's equations and their applications. Prerequisites: Mech 102 or 103; Math 205. Beer, Sarubbi, Delph

305. Advanced Mechanics of Materials (3) fall
Selected problems of stress and strain that are governed by ordinary differential equations such as combined bending and torsion of bars, curved bars, beams on elastic foundation. Membrane analogy. Principles of indeterminate analysis. Energy methods. Prerequisites: Mech 203 or equivalent; Math 205. Erdogan, Hilton

307. Mechanics of Continua (3) spring
Fundamental principles of the mechanics of deformable bodies. Study of stress, velocity and acceleration fields. Compatibility equations, conservation laws. Applications to two-dimensional problems in the theories of perfectly elastic materials and also perfectly plastic materials. Prerequisites: Mech 203 and 305. Rivlin, G. Smith

313. Fracture Mechanics (3) spring
Fracture behavior in solids, the Griffith theory and extensions to linear elastic fracture process models; stress analysis of cracks; generalization of fracture criteria; plasticity; subcritical crack growth, including environmental and thermal effects; fracture toughness testing; failure analysis and fracture control plans. Prerequisites: Mech 11 and Math 205. Roberts, Sih, Wei

323. (CE 324) Fluid Mechanics of Ocean and Atmosphere (3) fall
Hydrostatics of the ocean and atmosphere. Vertical stability. Fluid motion in a rotating coordinate system. Geostrophic flow; ocean currents; surface and internal waves. Prerequisite: ME 231 or CE 121. Macpherson

326. Aerodynamics (3) spring
Application of fluid dynamics to external flows. Simple exact solutions in two dimensions. Kutta condition at a trailing edge. Thin aerofoil theory, steady and unsteady flow. Lifting line theory. Flow past slender bodies. Linearized compressible flow. Far field solutions, shock formation. Prerequisites: ME 231 Math 208. Blythe, Venkataraman

350. Special Topics (3)
A study of some field of engineering mechanics not covered in the general courses. Prerequisite: consent of the chairman.

For Graduate Students

The graduate courses in mechanics are open in general to students who have been graduated from a curriculum in engineering mechanics, engineering mathematics, engineering physics, civil engineering, or mechanical engineering at a recognized institution.

A candidate for the master of science degree in applied mechanics is expected to possess a thorough knowledge of undergraduate mathematics and mechanics. Math 205, 208 and 322, and Mech 302 and 305, or their equivalents, are considered prerequisites for graduate work in applied mechanics. Any of these courses which have not been taken by the student as an undergraduate should be included in the graduate program. The student may then be required to present a larger number of credits than the minimum required for graduation. A thesis carrying six credit hours is required of all candidates for the master of science.

Current departmental research activities of interest include programs as follows:

Continuum mechanics. Formulation of field equations and constitutive equations in non-linear elasticity theories. Mechanics of viscoelastic solids and fluids. Plasticity theory. Generalized continuum mechanics. Thermomechanical and electro-mechanical interactions. Stress birefringence. Wave propagation. Finite amplitude wave propagation.

Fracture mechanics. Stress analysis of media containing inclusions or perforations, including visco-elastic, non-homogeneous, and anisotropic materials. Analysis of crack growth under static, periodic, and random loadings and environmental effects. Optimizations of fracture control. Crack propagation theories for non-linear materials. Influence of cracks on the strength of structural members.

Stochastic processes. Response of systems to stochastic inputs, including the effects of multi-dimensional fields and non-stationary processes. Prediction theory. Cumulative damage under random loads.

Thin shell analysis. Free vibration and dynamics response of elastic shells. Elastic-plastic deformations of shells upon cyclic thermal loadings. Applications of shell analysis to nuclear power plant components (pressure vessels, curved pipes), and to biological systems (eye, frog's eggs and other cells).

Fluid mechanics. Finite amplitude waves in stratified gases and fluids; shock propagation and problems related to the sonic "boom"; nonequilibrium and low density flows; boundary layer separation and wake models; flows of non-Newtonian fluids in flexible tubes; with application to hemorheology; magneto-fluid mechanics; wing theory; vortex-boundary layer inter-action; modelling of turbulent boundary layers; unsteady loading due to vortex shedding and impingement; unsteady flow in pipelines, diffusers, and turbomachinery cascades; modelling of two-phase flows.

Special departmental facilities of interest to the graduate student include the latest mechanical, electrodynamic and servocontrolled hydraulic testing machines, photoelastic bench, laser, and corrosion fatigue test facilities.

402. Advanced Analytical Mechanics (3)
Fundamental dynamical theorems and their applications to advanced problems; generalized coordinates; Lagrange's equations; fixed and moving constraints; nonholonomic systems; Hamilton's principle; Hamilton's canonical equations; contact transformations; Hamilton-Jacobi partial differential equation. Prerequisite: Mech 302 or consent of the department chairman. Beer, Johnson

405. Response of Systems to Random Loads (3)
Stochastic processes; correlation functions and power spectra; response of mechanical systems to one-dimensional and multidimensional random load fields; probability theory for several random variables; statistical properties of the random vibrations of mechanical systems; applications to failure prediction. Prerequisite: consent of the department chairman. Beer, Sarubbi

Mech 406. Advanced Dynamics and Vibrations (3) fall, 1979, and spring, 1981
Kinematical and mathematical preliminaries, basic notions of variational calculus; Hamilton's principle, Lagrange equations, discrete systems; dynamics of continuous systems, Sturm-Liouville theory, eigenvalue problems; transient and frequency response. There will be frequent examples of the application of these techniques to the analysis of shafts, beams, membranes, and plates. Prerequisites: ME 242 and Mech 302. Erdogan, Sarubbi

407. Wave Propagation in Solids (3) spring, 1981
Wave propagation in deformable elastic solids; problems in half-space and layered media; application of integral transformations. Erdogan, Delph

409. Theory of Elasticity I (3) fall
Kinematics of deformation, analysis of stress, stress-strain relations, strain energy function. Reciprocal theorem. Methods for two-dimensional boundary value problems applied to anti-plane, torsion, bending and plane problems. Approximate and numerical methods of solution. Prerequisites: Math 205; Mech 305 or equivalent course in advanced mechanics of material. Erdogan, Hartranft, Sih

410. Theory of Elasticity II (3)
Advanced topics in the theory of elasticity. The subject matter may vary from year to year and may include, e.g., theory of potential functions, linear thermoelasticity, dynamics of deformable media, integral transforms and complex-variable methods in classical elasticity. Problems of boundary layer type in elasticity; current developments on the micro-structure theory of elasticity. Prerequisites: Mech 409, Math 208, or consent of the chairman.

411. (Phys 471) Continuum Mechanics (3)
An introduction to the continuum theories of the mechanics of solids and fluids. This includes a discussion of the mechanical and thermodynamical bases of the subject, as well as the use of invariance principles in formulating constitutive equations. Applications of the theories to specific problems are given. Rivlin, G. Smith

412. Theory of Plasticity (3)spring 1980
Time independent mechanical behavior in simple tension, compression, and torsion. Time independent stress-strain relations for materials under combined stress. Application to problems with axisymmetric stress distributions. Loading, unloading, residual stresses, shakedown. Limit theorems of perfectly plastic bodies; applications. The slip line field for plane strain; examples. Plastic analysis of structures; frames, plates, shells. Finite element approach to problems. Time-dependent mechanical behavior of materials, creep. Prerequisites: Math 205; Mech 305 or equivalent course in advanced mechanics of materials. Kalnins, Updike

413. Fracture Mechanics (3) spring, 1980
Introduction to fracture mechanics criteria for bodies containing

cracks and notches; microscopic and macroscopic analytical modeling; fracture toughness concept; test specimens; stress intensity factor evaluation of crack systems; prediction of crack trajectory and direction of initiation; dynamic loading and crack propagation; fatigue crack growth and environmental effects; brittle-ductile transition phenomenon in metals; viscoelastic behavior of polymers. Prerequisite: Mech 203, Math 208, or consent of the department chairman. Erdogan, Sih, Wei

415. (CE 468) Stability of Elastic Structures (3)
Basic concepts of instability of a structure; bifurcation, energy increment, snap-through, dynamic instability. Analytical and numerical methods of finding buckling loads of columns. Postbuckling deformations of cantilever column. Dynamic buckling with nonconservative forces. Effects of initial imperfections. Inelastic buckling. Buckling by torsion and flexure. Variational methods. Buckling of frames. Instability problems of thin plates and shells. Prerequisite: Math 205. Kalnins

416. Analysis of Plates and Shells (3) fall, 1980
Bending of rectangular and circular plates, plates under lateral loads, plates with thermal and inelastic strains, effect of in-plane forces, large deflections, buckling of plates. Geometry and governing equations of shells, shells of revolution, membrane states, edge solutions, solution by numerical integration, nonsymmetric problems, buckling of shells, applications to pressure vessels. Prerequisites: Math 205; Mech 305, or equivalent course in advanced mechanics of materials. Kalnins, Updike

417. Mixed Boundary Value Problems in Mechanics (3)
General description of mixed boundary value problems in potential theory and solid mechanics. Solutions by dual series, dual integral equations and singular integral equations. Approximate and numerical methods. Erdogan

418. Finite Element Method (3)
The finite element method of continua is developed from relevant energy principles. Examples from elasticity, heat transfer, and fluid mechanics are used to illustrate alternative element choices and implementation. Applications to fracture mechanics and non-linear phenomena are discussed. The course includes the development and use of computer programs to perform the implied calculations. Prerequisites: Mech 305 or equivalent course, and knowledge of Fortran. Hilton

421. Fluid Mechanics (3)
Kinematics of fluid flow. Lagrangian and Eulerian descriptions. Basic conservation laws. Review of thermodynamics. Constitutive relations. Vorticity, circulation. Irrotational flow. Bernoulli theorems. Vortex motion, velocity motion, velocity potential, stream function. Potential flow in two and three dimensions. Compressible flow; sound waves, simple waves; gas dynamic discontinuities. Salathe

422. Fluid Mechanics (3)
Similarity and dimensional analysis. Exact solution for viscous incompressible flow. Singular perturbation theory, with application to flows at low and high Reynolds number. Hydrodynamic stability. Depending on interest, additional topics from magnetohydrodynamics, kinetic theory, wing theory, turbulence, water waves, flows in flexible tubes. Prerequisite: Mech 421. Salathe

424. Unsteady Fluid Flows (3)
Gas dynamics, finite amplitude disturbances in perfect and real gases; channel flows: three-dimensional acoustics; theories of the sonic boom. Motions in fluids with a free surface: basic hydrodynamics, small amplitude waves on deep water; ship waves; dispersive waves; shallow water gravity waves and atmospheric waves. Hemodynamics: pulsatile blood flow at high and low Reynolds number. Models of the interaction of flow with artery walls. Varley

437. (Met 437) Dislocations and Strengths in Crystals (3)
Theory and application of dislocations. Geometrical interpretation; elastic properties; force on a dislocation; dislocation interactions and reactions; multiplication. Dislocations in crystal structures. Selected topics in strengthening, plastic flow, creep, fatigue and fracture are discussed. Prerequisites: Math 205 or 221, or Met 320; Met 317, or consent of the chairman. Chou, Wei.

450. Special Problems (3)
An intensive study of some field of applied mechanics not covered in more general courses.

Metallurgy and Materials Engineering

Professors. Alan W. Pense, Ph.D., *chairman;* Betzalel Avitzur, Ph.D., director, Institute for Metal Forming; Sidney R. Butler, Ph.D.; Ye T. Chou, Ph.D.; George P. Conard II, Sc.D.; Joseph I. Goldstein, Sc.D., Theodore L. Diamond, professor; Walter C. Hahn, Jr., Ph.D.; Richard W. Hertzberg, Ph.D., New Jersey Zinc professor; R. Wayne Kraft, Ph.D.; Joseph F. Libsch, Sc.D., Alcoa professor and vice president for research; Donald M. Smyth, Ph.D., director, Materials Research Center; Richard M. Spriggs, Ph.D., vice president for administration (on leave 1979); Robert D. Stout, Ph.D., dean of the Graduate School; S. Kenneth Tarby, Ph.D.; David A. Thomas, Ph.D.; associate director, Materials Research Center; John D. Wood, Ph.D.
Associate professor. Michael R. Notis, Ph.D.
Assistant professor. Subhash H. Risbud, Ph.D.; David B. Williams, Ph.D.

Progress in many fields of engineering depends upon discovery of new materials and a better understanding of the behavior of existing materials.

Interest in new materials for solid-state devices, for application of nuclear energy and for space technology, as well as a better understanding of the behavior of materials in the design of structures, automobiles and aircraft, plant processing equipment, electrical machinery, etc., have increased the need for people trained in the science and technology of metals and other materials.

Training for this field of engineering requires basic studies in mathematics, chemistry, physics and mechanics, plus a general background in engineering principles, followed by intensive training in the application of scientific and engineering principles to the development and use of materials in a technological society. In addition, the curriculum offers an introduction to humanistic and social studies which broaden the student's outlook and enhance professional development after graduation.

The objective of the program is to combine a fundamental understanding of the behavior of materials from the electronic, atomic, crystallographic, microstructural and macrostructural viewpoints with knowledge of the technology of materials preparation and processing. The student thus receives a broad education with emphasis on the factors which govern the mechanical, physical and chemical properties of materials to aid in the analysis, development, selection and use of materials for all types of industries.

The curriculum in metallurgy and materials engineering is designed to train graduates for research, development, operations, management and sales careers in industry or for graduate study in metallurgy and materials engineering. While some graduates go directly into metal producing companies, a large proportion serve as metallurgists or materials engineers in the chemical, electrical, transportation, communications, space and other metal and materials consumer industries. A number of students pursue graduate study for university teaching and research careers.

Special programs and opportunities include the bachelor of science in engineering and the masters in materials. The undergraduate research option and industrial option also are described.

Major Requirements

The recommended sequence of courses is shown. The standard freshman year is shown on page 43.

sophomore year, first semester (17 credits)*

Math 23	Analytical Geometry and Calculus III (4)	
Phys 21, 22	Introductory Physics III & Laboratory (5)	
Eco 1	Economics (4)	
Met 63	Engineering Materials & Processes	*or*
Met 91	Elements of Materials Science	*or*
	General Studies elective (3)	
Met 10	Metallurgy laboratory	*or*
ME 21	Mechanical Engineering Laboratory (1)	

*Met 10 or ME 21 and Met 63 or 91 are required and should normally be taken during the sophomore year. However, they may be taken in the first semester of the junior year.

sophomore year, second semester (15-16 credits)

Math 205	Linear Methods	*or*
Math 231	Probability and Statistics (3)	
EE 160	Electrical Circuits & Apparatus	*or*
Phys 31	Introduction to Quantum Mechanics (3-4)	
Mech 1	Statics (3)	
	General Studies elective (3)	
Met 63	Engineering Materials & Processes	*or*
Met 91	Elements of Materials Science	*or*
	General Studies elective (3)	

junior year, first semester (18 credits)

ChE 60	Unit Operations (3)
Chem 207	Metallic Elements (3)
Mech 11	Mechanics of Materials (3)
Met 207	Electronic and Crystal Structure (3)
Met 210	Metallurgical Thermodynamics (3)
	General Studies elective (3)

junior year, second semester (16-17 credits)

ME 166	Procedures for Mechanical Design	*or*
Mech 102	Dynamics (2-3)	
Met 101	Professional Development (1)	
Met 208	Phase Diagrams and Transformations (3)	
Met 218	Mechanical Behavior of Materials (3)	
Met 304	Extractive Metallurgy I (4)	
	elective (3)	

summer

Met 100	Summer Employment

senior year, first semester (15-18 credits)

Met 305	Extractive Metallurgy II (3)
Met 307	Structure and Behavior of Materials (3)
Met 313	Materials Fabrication (3)
	engineering science elective (3)
	electives (3-6)*

senior year, second semester (15-18 credits)

Met 278	Metallurgical Reports (3)
Met 358	Selection of Materials (3)
	engineering science elective (3)**
	approved elective (3)
	General Studies elective (3)
	elective (0-3)*

*Please refer to description of normal program, page 43.
**Engineering science electives include, for example, ChE 41, 52, 320 321; Chem 187, 312, 393, 396; CE 106, 121, 222; EE 11, 20, 103; IE 168, 205, 206, 212; Mech 102, 203, 313; and Met 312, 314, 333, 334.

In addition to the regular program, there are two options in the curriculum oriented to emphasize 1. industrial metallurgy, and 2. preparation for graduate research in materials.

Industrial Metallurgy Option

The industrial metallurgy option is designed to prepare students in a four-year program as plant metallurgists or materials engineers. To assist in this objective, students electing the option take two special courses, Met 327 and 329, in place of an equivalent number of other specified courses. The emphasis in these courses is a team approach to the solution of actual plant problems.

The course is conducted in cooperation with local industries. Three days per week are spent at the plant of the cooperating industry on investigations of selected problems in plant operations. The option is limited to a small group of seniors selected by the department from those who apply. Summer employment is provided when possible for those who elect to initiate the program during the summer preceding the senior year.

junior year
same as regular program

summer

Met 100	Industrial Employment

senior year, first semester (17-20 credit hours)

Met 327	Industrial Metallurgy (4)
Met 329	Industrial Metallurgy (4)
Met 305	Extractive Metallurgy II (3)
Met 307	Structure and Behavior of Materials (3)
Met 313	Materials Fabrication (3)
	elective (0-3)*

senior year, second semester (17 credit hours)

Met 338	Metallurgy Colloquium (2)
Met 358	Selection of Materials (3)
	Approved elective (3)
	General Studies elective (3)
	engineering science elective (6)**

*Please refer to description of normal program, page 43.
**Engineering science electives include, for example, ChE 41, 52, 320, 321; Chem 187, 312, 393, 396; CE 106, 121, 222; IE 168, 205, 206, 212; EE 11, 20, 103; Mech 102, 203, 313; Met 312, 314, 333, 334.

Research Option

For those students who may be interested in teaching, research, or development, and intend to pursue graduate work, a research option is offered. In this option, students take Met 240 and 291. Financial support may be available for those students who elect to initiate a research program during the summer preceding the senior year. The option is limited to a small group of selected students.

junior year, second semester (18-19 credits)
same as regular program with the following addition:

Met 240	Research Techniques (2)

summer

Met 100	Industrial Employment	*or*
	Undergraduate Summer Research	

senior year, first semester (15-18 credit hours)

Met 291	Experimental Metallurgy (3)
Met 305	Extractive Metallurgy II (3)
Met 307	Structure and Behavior of Materials (3)
Met 313	Materials Fabrication (3)
	elective (3-6)*

senior year, second semester (17 credit hours)

Met 338	Metallurgy Colloquium (2)
Met 358	Selection of Materials (3)
	Approved Elective (3)
	General Studies elective (3)
	engineering science elective (6)

*Please refer to description of normal program, page 43.
**Engineering science electives include, for example, ChE 41, 52, 320, 321; Chem 187, 312, 393, 396; CE 106, 121, 222; IE 168, 205, 206, 212; EE 11, 20, 103; Mech 102, 203, 313; and Met 312, 314, 333, 334.

Undergraduate Courses

10. Metallurgy Laboratory (1) fall
Application of equipment for laboratory study of structure and properties of metals. Prerequisite: Met 63 or 91 previously or concurrently.

63. Engineering Materials and Processes (3) fall-spring*
Engineering materials and their properties. Methods and effect of

fabrication and treatment. Application and use of materials in engineering. Primarily metals, but including plastics, ceramics, and other engineering materials. Prerequisites: Chem 21; Phys 11 or 16.

91. Elements of Materials Science (3) fall-spring*
Introductory study of the relationship between structure (on the atomic, crystallographic or molecular, micro and macro scales) and physical and mechanical properties of metallic, ceramic, and polymeric materials. Influence of processing variables on structure and properties. Lectures and recitation. Prerequisites: Chem 21; Phys 21 or 16 previously or concurrently.

92. Structure and Properties of Materials (3) spring*
A unified chemical-physical approach to the structure and properties of metallic, nonmetallic and composite materials of construction. Laboratories and lecture examples emphasizing structure, mechanical properties, and materials applications. Prerequisites: Chem 21, Phys. 21. Thomas
**Only one of these three courses may be applied for graduation credit by each student.*

100. Industrial Employment
In the summer following the junior year, students in metallurgy and materials engineering are required to secure at least eight weeks of experience in industrial plants or research organizations. A written report is required.

101. Professional Development (1) spring
Meetings with the department staff for the purpose of developing a professional outlook of the engineering student. Required reading, oral reports and term papers. Prerequisite: junior standing. Prerequisite: consent of the department chairman.

For Advanced Undergraduates and Graduate Students

204. Nonmetallic Materials of Construction (3) fall
The principles and technology of nonmetallic materials of present and future use in structural applications. Manufacturing methods and mechanical and environmental properties, with emphasis on composite materials such as concrete, fiber-reinforced and foamed polymers, and laminates. Lectures and some field trips or laboratories. Prerequisite: Mech 11 or consent of the department chairman. Thomas

207. Electronic and Crystal Structure (3) fall
Atomic theory, chemical bonding, lattice concepts, and theory of X-rays. Nature of crystalline phases, imperfections, and atom movements. Electron theories of solids. Lectures and laboratory. Prerequisites: Met 10, Mech 13 or ME 21 previously or concurrently, and Phys 21.

208. Phase Diagrams and Transformations (3) spring
Thermodynamic basis for equilibrium. The phase rule. Equilibrium phase diagrams and nonequilibrium considerations. Solidification and solid state phase changes. Rationalizations of microstructures. Recovery, recrystallization, and gain growth. Lectures and laboratory. Prerequisites: Met 207, and 210.

210. Metallurgical Thermodynamics (3) fall
The applications of thermodynamic relations to metallurgical processes with emphasis on solving specific problems for processes such as the open hearth for steel, heat treating atmospheres, alloy equilibrium diagrams, and others. Lectures and problem sections. Prerequisite: Math 23. Hahn

213. Materials Systems Analysis (3)
Study of application of materials science principles to the solution of materials engineering problems. Interrelation between basic concepts and the selection of complete materials systems, which consist of the fabricating process and finishing sequence, for particular design requirements. Materials covered will be metals, polymers, ceramics and composites. Not open to majors in metallurgy and materials engineering. Lecture and laboratory. Prerequisite: Met 63 or 91 or equivalent of either course. Wood

218. Mechanical Behavior of Materials (3) spring
Deformation and fracture behavior of materials. Elastic and plastic behavior, with emphasis on crystallographic consideration. Strengthening mechanisms in solids. Static and time-dependent fracture from metallurgical and continuum viewpoints. Lectures and laboratory. Prerequisites: Mech 11, Met 207, and Met 63 or Met 91. Hertzberg

Met 221. (HPT 221) Materials in the Development of Man (3)
Development of materials technology and engineering from the stone age to atomic age as an example of the interaction between technology and society. In-class demonstration laboratories on composition and structure of materials. Term projects using archaeological material and alloys. Course intended for, but not limited to, students in the humanities and secondary-science education. Engineering students may not use this course for engineering science or technical elective credit. Notis

240. Research Techniques (2-3) spring
Study, analysis and application of experimental techniques in metallurgical and materials research. Analysis of experimental data and methods of presentation. Design of experimental programs. Recitations and laboratory. Restricted to small numbers of students by the department chairman.

278. Metallurgical Reports (3) spring
An opportunity for the advanced student to develop familiarity with current metallurgical literature and to present oral reports and a comprehensive written survey. Prerequisite: senior standing.

291. Experimental Metallurgy (3)
Application of research techniques to a project in metallurgy or materials engineering selected in consultation with the senior staff. Prerequisite: Met 240.

300. Apprentice Teaching in Metallurgy (1-3)
See the introduction to Section V for an explanation.

304. Extractive Metallurgy I (4) spring
A unit process study of extractive metallurgy techniques. Includes chemical principles, thermochemistry and kinetics; also phases in pyrometallurgical systems, combustion of fuels and refractories. The preparation, treatment, and handling of materials for primary crude metal production. Lectures plus laboratory. Prerequisite: ChE 60 and Met 210. Hahn

305. Extractive Metallurgy II (3) fall
Continuation of Met 304. A detailed engineering analysis of important metallurgical processes. A study of the thermodynamic and kinetic aspects of these processes. Development of mathematical models of processes by computer programming. Lectures, laboratory and plant trips. A three-day inspection trip is required. Prerequisite: Met 304. Tarby

306. Optimization of Metallurgical Processes (3)
Numerical methods are used to investigate metallurgical reactions and processes. Problems relating to the optimization of processes in the ferrous and nonferrous fields are studied. Lectures and computer-oriented problems. Prerequisites: a knowledge of computer programming and consent of the department chairman. Tarby

307. Structure and Behavior of Materials (3) fall
Correlation of structure and properties of engineering materials. Design of thermal, chemical, and mechanical treatments to develop optimum properties in metals, ceramics and polymers. Lectures and laboratory. Prerequisites: Met 218 and Met 208. Pense

311. Metallic Materials for Structures (3) fall
The structure and behavior of structural steels, aluminum and other alloys, with emphasis on materials used in large-scale engineering structures such as bridges, buildings and pressure vessels. Fracture mechanics concepts, the physical metallurgy of alloys involved, and fabrication of structures, especially welding. The relationship between materials, fracture control and fabrication. Metallurgy majors may take only with the consent of the department chairman. Lectures and laboratory. Prerequisite: Met 63 or equivalent. Hertzberg, Pense

312. (ChE 312) Fundamentals of Corrosion (3)
Corrosion phenomena and definitions. Electrochemical aspects

including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization, and passivity. Nonelectrochemical corrosion including mechanisms, theories, and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings, alloys, inhibitors, and passivators. Prerequisites: Met 210, Chem 187, or equivalent of either.

313. Materials Fabrication (3) fall
Basic concepts of stress, strain and stress-strain behavior under load. Analysis and description of metal forming, metal cutting, casting, joining, and powder metallurgy. Lectures and laboratory. Prerequisite: Met 63 or Met 91, or equivalent. Avitzur

314. Advanced Metal Forming (3)
Extension of Met 313. Topics to be included: friction, lubrication and wear, failure and damage in metal forming, and deformation in composite metals and in powder metallurgy. Forming alternatives for specific products such as cans, tubes, wires and others will be compared. Recent developments of new forming processes. Prerequisite: Met 313. Avitzur

315. Introduction to Physical Ceramics (3)
Methods of fabrication, physical properties, and applications of ceramic materials, including oxides, carbides, nitrides, borides and silicides. Correlation of atomic bonding, micro structure and physical behavior in service environments. Special topics, including electronic ceramics, nuclear ceramics, refractories, cutting tools and abrasives. Prerequisites: Chem 21 and Phys 11 or consent of the department chairman. Risbud

316. Physical Properties of Materials (3)
Consideration of observed electrical, magnetic, thermal and optical properties of crystalline materials with emphasis on their relationship to electron configuration and crystal structure. Lectures and demonstrations. Prerequisite: Met 207 or Phys 31, or consent of the department chairman. Notis, Conard or Butler

317. Imperfections in Crystals (3)
The types of imperfections in crystals and their effects on the behavior of crystalline materials with particular emphasis on dislocations. Prerequisite: Met 63 or 91, or equivalent. Chou

319. Current Topics in Materials Science (3)
Selected topics of current interest in the field of material engineering but not covered in the regular courses. May be repeated for credit with consent of the department chairman. Prerequisites: Met 210 and 218.

320. Analytical Methods in Materials Science (3)
Selected topics in modern analysis and their application to materials problems in such areas as thermodynamics, crystallography, deformation and fracture, and diffusion. Prerequisite: Math 231 or 205. Chou

322. Materials Technology in the Energy Crisis (3) spring
Impact of materials on energy including nuclear and solar energy and solar cells, coal gasification, MHD power generation and superconductors. Energy resources, conversion, and consumption. Materials limitations on development of energy alternatives in transportation, power and primary metals industries. Industry and government lecturers participate. Prerequisite: Met 63 or 91, or consent of the department chairman. Notis

327. Industrial Metallurgy (4) fall
Restricted to a small group of seniors and graduate students selected by the department from those who apply. Three full days per week are spent at the plant of an area industry for research in plant operations. Application by a graduate student for admission to this course must be made prior to March 1 of the previous semester. Tarby, Hahn, Notis

329. Industrial Metallurgy (4)
To be taken concurrently with Met 327. Course material is the same as Met 327.

333. (Geol 337) X-ray Methods (3) fall
Fundamentals and experimental methods of X-ray techniques. Application to various materials problems including diffraction, radiography, fluorescent analysis, lectures and laboratory equivalent. Kraft

334. (Geol 338) Electron Metallography (4) spring
Fundamentals and experimental methods in electron optical techniques included scanning electron microscopy (SEM) conventional transmission (TEM) and scanning transmission (STEM) electron microscopy. Specific topics covered will include electron optics, electron beam interactions with solids, electron diffraction and chemical microanalysis. Applications to the study of the structure of materials are given. Prerequisite: consent of the department chairman. Williams, Goldstein

338. Metallurgical Colloquium (2) spring
An opportunity for the student to develop an acquaintance with the current metallurgical literature, the ability to interpret such literature clearly, and skill in presenting oral engineering reports. Prerequisite: consent of the department chairman

343. (ChE 393, Chem 393) Physical Polymer Science (3)
Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline and paracrystalline states (including viscoelastic and relaxation behavior) for single and multicomponent systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology and behavior. Prerequisite: one year of physical chemistry.

358. Selection of Materials (3) spring
Problems relating to design and service requirements of material components. Selection of materials fabrication and finishing processes. Failure analysis. Discussion of specific examples involving materials. Lectures and problems. Prerequisites: Met 307 and Met 313, or consent of the department chairman. Wood

361. Physics of Materials (3)
Principles of quantum mechanics and statistical thermodynamics. Intended to provide a basic understanding of the principles underlying the study of structure and properties of materials. Prerequisites: Met 91 or equivalent; Math 205.

396. (Chem 396) Chemistry of Nonmetallic Solids (3)
Chemistry of ionic and electronic defects in nonmetallic solids and their influence on chemical and physical properties. Intrinsic and impurity-controlled defects, nonstoichiometric compounds, defect interaction. Properties to be discussed include: diffusion, sintering, ionic and electronic conductivity, solid-state reactions, and photoconductivity. Prerequisite: Chem 187 or Met 210 or equivalent. Smyth

For Graduate Students

The department offers three degrees: a master of science, a master of engineering, and a doctor of philosophy in metallurgy and materials engineering.

A diversity of program and curricula are available to a person interested in graduate study in the area of materials. The department of metallurgy and materials engineering generally is the department from which a degree is earned. However, thesis and dissertation research may be a part of programs under way in the department or at the Materials Research Center or other departments or centers.

The department of metallurgy and materials engineering has both a large enough staff and graduate enrollment to enable it to suit the needs of students whose interests range from the science of materials through materials engineering and metallurgy. At the same time, those advanced students who want it are usually provided the opportunity to gain experience in teaching under the guidance of the senior staff.

The foundation for successful graduate work in the department includes sound preparation in chemistry, physics and mathematics, and adequate breadth of general education. Candidates entering the department who have obtained their previous degrees in fields other than metallurgy or materials engineering may be required to take certain undergraduate courses without credit toward the graduate degree.

The programs of the department are flexible. Upon acceptance, each student is assigned a faculty adviser. Under the adviser's direction, the student plans a course of study to satisfy individual needs and interests.

Most advanced-degree recipients find careers in industry or

industrial or governmental research and development laboratories. A smaller number have gone into teaching, consulting or academic research.

Graduate facilities for research are located in the Whitaker Laboratory, in the interdisciplinary Materials Research Center, the Sherman Fairchild Laboratory, and other associated laboratories. The laboratories are well equipped with both generalized equipment as well as specialized sophisticated equipment which is available to graduate students.

Specialized equipment such as conventional and scanning transmission electron microscopes, scanning electron microscope, electron microprobe, X-ray diffraction units, closed-loop mechanical testing equipment, and crystal-growing and zone-processing equipment are maintained and operated by skilled technicians. After receiving the required instructions, graduate students operate this equipment.

The university supplements departmental facilities with a CDC 6400 computer system and the Mart Science and Engineering Library.

Special Programs and Opportunities

The department has established specific recommended programs for the master of science, the master of engineering and doctor of philosophy degrees, emphasizing the following areas: chemical metallurgy, materials engineering, materials science, mechanical metallurgy, physical ceramics, and physical metallurgy.

These programs are not rigid. The program in chemical metallurgy offers a cooperative "Chem.-Met." program with the chemical engineering department. The emphasis of the mechanical metallurgy program is on the analysis of metal-forming operations. Many students, however, have specialized in other areas of mechanical metallurgy, such as deformation and fracture analysis, either through combined programs in physical and mechanical metallurgy or through cooperation with the department of mechanical engineering and mechanics and the Materials Research Center. The physical ceramics program emphasizes the study of the mechanical and physical behavior of various ceramic systems.

The department also cooperates with the chemical engineering and chemistry departments in graduate programs in polymer science.

Major Requirements

Graduate school requirements are explained in Section IV. In the department of metallurgy and materials engineering, a candidate for the degree of master of science completes a thesis. This normally represents six of the thirty semester hours required for this degree. Candidates for the degree of master of engineering complete a three-credit engineering project.

A candidate for the Doctor of Philosophy prepares a preliminary program of courses and research providing for specialization in some phase of metallurgy, materials science, or materials engineering (largely through research) in consultation with the adviser. Prior to formal establishment of the doctoral program by the special committee and its approval by the Graduate School, the student passes a qualifying examination which must be taken early in the first year of doctoral work. The department does not require a foreign language. It does require preparation and defense of a research proposal as a portion of the general examination.

Of the courses listed above only those in the 300 series are available for graduate credit for students in metallurgy and materials engineering. There are many additional offerings in materials under the listings of other departments.

Most graduate students receive some form of financial aid. Several kinds of fellowships, traineeships, and assistantships are available. This type of aid generally provides for tuition, and allowance for experimental supplies, and a stipend. To date, the Internal Revenue Service has allowed this stipend to be tax-free. For details of graduate scholarships, fellowships and assistantships, please refer to Section IV.

Research Activities

Graduate students conduct their research in facilities located in the department or the Materials Research Center, or other centers and institutes. The following list of activities notes the many areas of interest. Asterisks (*) indicate research of an interdisciplinary nature.

chemical metallurgy. Kinetics of metallurgical reactions; mathematical modeling of metallurgical processes; thermodynamics of metallic solutions; thermodynamics and phase equilibria.

materials science. Characterization of metal oxide films*; crystal growth*; defect chemistry and electrical properties of insulating and semiconducting oxides*; deformation and recrystallization texture studies; deformation of bicrystals; dislocation studies; eutectic research including solidification, microstructure, and property studies*; magnetic materials; meterorites and lunar materials; photoelectric studies of insulators; preparation and properties of materials for solid state devices*; processing of metal insulator semiconductor structures and their evaluation and application to integrated circuits*; quantitative metallography; structure and behavior of solid-state materials*; structure and properties of sputtered, evaporated, and plated thin films*.

mechanical metallurgy. Cladding and forming of composite materials; correlation of microstructure with mechanical behavior of low-alloy, high-strength steels, especially fatigue, creep and brittle fracture; deep drawing, impact extrusion and ironing; deformation and fracture of eutectic composites; ductile fracture; effect of holes, inclusions and pressure on the tensile properties; electron fractography*; environmental crack kinetics*; fatigue crack propagation studies of metals and polymers*; flow through converging conical dies; forming of polymers*; friction measurement; hydrostatic extrusion; influence of welding on fatigue characteristics of weldments*; mechanical behavior of anisotropic materials*; pressure-induced ductility; theoretical analysis of metal forming methods and correlation with metallurgical parameters; toughness of weld metal; weldability of steels.

physical ceramics. Electrical properties of electronic ceramics*; thermal diffusivity of ceramic materials*; hot pressing studies*; grain growth in oxides*; electrical and magnetic properties of oxides*; creep modeling of ceramics*; electron microscopy of dislocation structures*; defect chemistry and electrical properties of ceramic oxides*.

physical metallurgy. Computerized materials selection; creep-rupture and aging, brittle fracture characteristics, and fatigue properties of low-alloy, high-strength steels*; diffusion-controlled growth; embrittlement mechanisms in steel; kinetics of solid-state reactions*; metallurgical factors affecting machining*; physical metallurgy of aluminum alloys; physical metallurgy of sintered carbides*; recrystallization; strengthening mechanisms; structure and morphology of martensite; tempering; ternary diffusion; transformation during joining; transmission electron microscopy of crystal defects; X-ray measurement of residual stresses*.

polymers. Environmental effects on polymers to protect concrete against corrosion*; fatigue crack propagation in engineering plastics*; fracture surfaces of crystalline polymers*; ion transport in polymer membranes; mechanical behavior of interpenetrating networks*; mechanical behavior of polyvinyl chloride*; mechanisms of sintering of polymers*; micromechanics of polymer fracture*; polymers from renewable resources; properties of polymer composites*; reclamation of scrap polymeric materials*; reinforcement of silicone rubber by silica fillers*; second-order transitions in cellulose triesters.

Graduate-Level Courses

406. Solidification (3)
Structure, theory and properties of liquids. Homogeneous and heterogeneous nucleation theory and experimental results.

Solidification phenomena in pure, single and multiphase materials including the natures of the freezing interface, segregation, constitutional super-cooling, dendritic growth, crystallographic effects, the origin of defects, crystal growing, zone processes. Prerequisite: consent of the chairman. Kraft

407. Theory of Alloy Phases (3)
Equilibrium portrayal and prediction. The emphasis is on systems of three or more independent variables. For the latter, consideration is given to the various factors, both "physical" and thermodynamic, which influence, and may permit prediction of, equilibrium phase structures and their range of stability. Examples are considered of the extension of such approaches to property prediction. Prerequisite: An undergraduate course in equilibrium diagrams, e.g. Met 208. Conard

408. Transformations (3) fall
The thermodynamic, kinetic and phenomenological aspects of a wide spectrum of solid-state phase transformations. Theories of nucleation, growth and coarsening of second phase precipitates. Application of the theories to continuous and discontinuous reactions, massive, martensitic and bainitic transformations in metals. Transformations in non-metallics. Prerequisites: Met 208 and 210. Williams

409. Current Topics in Materials (3)
Recent practical and theoretical developments in materials. This course may be repeated for credit if new material is covered. Prerequisite: consent of the department chairman.

410. Physical Chemistry of Metals I (3) fall
Discussion of reactions involving gases and reactions involving pure condensed phases and a gaseous phase. Ellingham diagrams and equilibria in metal-oxygen-carbon systems. Consideration of the behavior of solutions and methods for determining thermodynamic properties of solutions by experimentation and computation. Prerequisite: Met 210 or equivalent. Tarby

411. Modern Joining Methods (3)
The foundations upon which the joining processes rest; the present limitations of the various processes; the trends in new developments; the engineering and structural aspects of joining. Prerequisites: Met 208 and 218. Pense

412. Magnetic Properties of Materials (3)
Fundamental concepts of magnetism and magnetic properties of ferro- and ferrimagnetic materials. Metallic and nonmetallic materials. Current application areas considered as examples. Prerequisite: Phys 31 or 363 or equivalent. Butler, Conard or Notis

413. Analysis of Metal Forming Processes (3)
Three-dimensional stress and strain analysis. Yield criteria, plastic flow and the upper and lower bound theorems. Analysis of metal forming processes, including drawing and extrusion, press work, rolling and spinning. The emphasis is on presenting several approaches to each problem. Avitzur

414. Physical Chemistry of Metals II (3) spring
Presentation of free energy-composition and phase diagrams of binary systems. Evaluation of lattice stability parameters. Consideration of reaction equilibria in systems containing components in condensed solutions, including compound formation, oxide phases of variable composition, solubility of gases in metals. Alternative standard states and interaction parameters for solutions. Prerequisite: Met 410. Tarby

415. Mechanical Behavior of Ceramic Solids (3)
Strength, elasticity, creep, thermal stress fracture, hardness, abrasion and high-temperature deformation characteristics of single- and multi-component brittle ceramic solids. Statistical theories of strength, static and cyclic fatigue, crack propagation, fracture toughness. Correlation of mechanical behavior, microstructure, and processing parameters. Prerequisite: Met 218 or consent of the department chairman.

416. Atom Movements (3)
Phenomenological and atomistic development of the laws of diffusion and their solution. Influence of gradients of concentration, potential, temperature and pressure. Effects of structural defects on diffusion in metals and nonmetals. Prerequisites: Math 23 and Chem 196 or the equivalent. Goldstein or Hahn

417. Deformation and Strength of Solids (3)
Topics related to deformation of solids including creep, strengthening mechanisms, annealing of deformed solids, preferred orientation. Primary emphasis is on crystalline materials. May be repeated for credit if different material is covered. Prerequisite: Met 218 or equivalent. Chou, Conard, Hertzberg, Kraft or Notis

418. Fatigue and Fracture of Engineering Materials (3) fall
Application of fracture mechanics concepts to the fatigue and fracture of crystalline and amorphous solids. Fracture control design philosophies. Metallurgical aspects of fracture toughness and embrittlement susceptibility. Environment-enhanced cracking. Fatigue crack propagation in metals and polymers. Electron fractography. Failure analysis case histories. Prerequisite: Met 218 or equivalent. Hertzberg

419. Alloy Steels (3)
Structures and transformations in iron and iron-based alloys. Design and heat treatment of alloys for stength, toughness, creep, and corrosion resistance. Prerequisite: Met 307. Pense

421. Fracture Analysis (3)
Application of fracture mechanics concepts, microstructural analysis, and fracture surface characterization to the analysis and prevention of engineering component failures. Extensive use of case histories. Introduction to legal aspects of product liability. Prerequisite: Met 218 or 311 or Mech 313 or equivalent. Hertzberg

422. Electrical Properties of Materials (3)
Electrical transport properties of metallic, semiconducting and insulating materials. Brief review of energy band concepts including surface and contact effects. Photo conduction and contact phenomena. Prerequisite: Phys 31 or 363 or equivalent. Butler, Conard or Notis

423. Advanced Transmission Electron Microscopy (3)
The theory and practice of operation of the transmission and scanning transmission electron microscope. Techniques covered include bright field, high resolution and weak-beam dark field, lattice imaging, diffraction pattern indexing and Kikuchi line analysis. The theory of diffraction contrast is applied to the interpretation of electron micrographs. Specimen preparation techniques. Prerequisite: Met 334 or equivalent. Williams

425. Topics in Materials Processing (3)
Topics such as: ceramics, metal, and polymer synthesis and compaction phenomena. Theories of sintering and grain growth. Physical behavior of sintered compacts. Techniques of fiber and crystal growth. Vapor deposition and ultra-high-purity materials preparation. Desirable preparation: Met 208, 218, 315. Prerequisite: consent of the department chairman.

427. Advanced Scanning Electron Microscopy (3)
The theory and practice of operation of the scanning electron microscope and electron microprobe. Techniques covered will include high-resolution scanning, quantitative electron probe microanalysis. Electron beam sample interactions, X-ray spectrometry, and electron optics will be discussed in detail. Prerequisite: Met 334 or equivalent. Goldstein

437. (Mech 437) Dislocations and Strength in Crystals (3)
Theory and application of dislocations. Geometrical interpretation; elastic properties; force on a dislocation; dislocation interactions and reactions; multiplication. Dislocations in crystal structures. Selected topics in strengthening, plastic flow, creep, fatigue and fracture are discussed. Prerequisites: Math 205 or 221, or Met 320; Met 317, or consent of the department chairman. Chou, Wei

443. (Chem 443) Solid-State Chemistry (3)
Crystal structure, diffraction in crystals and on surfaces, bonding and energy spectra in solids, dielectrics, surface states and surface fields in crystals. Prerequisite: Chem 191 or equivalent. Smyth

458. Materials Design (3)
Analysis of design requirements for materials components. Selection of materials and processes. Study of failures in process and service and application of recent metallurgical and materials engineering knowledge for improved design. Solution and discussion of industrial problems, and outline of experimental approach. Prerequisite: consent of the chairman. Wood

460. Engineering Project (1-3)
In-depth study of a problem in the area of materials engineering or design. The study is to lead to specific conclusions and be embodied in a written report. Intended for candidates for the master of engineering degree. May be repeated for a total of three credit hours.

461. Advanced Materials Research Techniques (3)
Study of the theory and application of selected advanced techniques for investigating the structure and properties of materials. May be repeated for credit with the approval of the department chairman.

482. (Chem 482, ChE 482) Engineering Behavior of Polymers (3) spring
A treatment of the mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analogs. Topics include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizers, moisture and aging on mechanical behavior.

484. (Chem 484, ChE 484) Crystalline Polymers (3) spring
An in-depth treatment of the morphology and behavior of both polymer single crystals and bulk crystallized systems. Emphasis is placed on the relationship between basic crystal physics, thermal and annealing history, orientation and resulting properties. A detailed discussion of the thermodynamics and kinetics of transition phenomena and a brief treatment of hydrodynamic properties and their relationship to crystallization and processing properties. Prerequisites: ChE 392 or 393 or equivalent.

485. (Chem 485, ChE 485) Polymer Blends and Compositions (3) fall
An intensive study of the synthesis, morphology, and mechanical behavior of polymer blends and composites. Mechanical blends, block and graft copolymers, interpenetrating polymer networks, polymer impregnated concrete, and fiber and particulate reinforced polymers are emphasized. Prerequisite: any introductory polymer course or equivalent.

Military Science

Professor. Lt. Col. Arthur J. Phelan, M.Ed., *chairman.*
Assistant professors. Capt. Ronald F. Romick, M.S.; Capt. Fayrene J. Schultz, MBA.; Capt. Michael Lynch, B.S.
Instructors. SGM Joseph R. Kress; MSG Richard A. Basilici.

The department of military science offers courses related to the Army ROTC program. This program is designed to accomplish the following goals: develop self-confidence and innate leadership and management ability, and provide a fundamental understanding of the Army's organization and responsibility.

These objectives are approached by utilizing numerous techniques, including academic classroom instruction, leadership laboratory, and adventure-type field trips. The leadership laboratory and field trips, which are based on classroom instruction, are both enjoyable and beneficial. A concept of modular electives has been instituted which permits students to select the activity which most interests them. The following modules are presently available: first aid, mountaineering, survival, marksmanship, orienteering, and conflict simulations. Voluntary field trips in all of the activities are conducted throughout the year.

Army ROTC offers a four-year program and a two-year program. The four-year program consists of a two-year basic course and the two-year advanced course. Basic-course students have no obligation to the Army taking these classes. Those in the advanced course do have such an obligation.

Basic Course

The basic course, normally taken in the freshman and sophomore years, provides training in basic military subjects such as leadership and management, military history, basic tactics, marksmanship, communications, and land navigation.

Advanced Course

The advanced course is normally taken in the junior and senior years. The instruction includes leadership and management, military tactics, logistics, administration, military law, and teaching methods. Students receive $100 per month subsistence pay during the junior and senior years.

A six-week advanced course summer training camp is normally held between the junior and senior year. Payment to the student for attending this camp is $450 plus travel expenses. The summer camp experience, in coordination with respective engineering curricula, may be used to fulfill the requirements of the engineering courses ChE 100, CE 100, EE 100, IE 100, ME 100, and Met 100, Industrial Employment.

To enroll in the advanced course, an applicant: 1. completes either the basic course or the six-week basic summer camp; 2. is accepted for enrollment by the university and the department of military science.

Uniforms and equipment. All uniforms, textbooks and equipment needed by the student for military science courses are supplied by the department. Students are charged for those items not returned at the appropriate date.

Transfers. Qualified students transferring from another institution may enter the ROTC program at the appropriate advanced level and year, provided they have received the necessary credits, the recommendation of their former professor of military science (if applicable), and the approval of the university.

Obligation after graduation. Usually upon graduation a student will receive a reserve commission as a second lieutenant and will serve on active duty for three years. Depending on Army requirements, a three- to six-month active duty for training with an eight-year reserve commitment is offered. Recipients of a Regular Army commission serve at least three years on active duty. Scholarship students agree to accept a Regular Army commission if offered and also serve four years on active duty. Graduates accepted for the Army aviation program serve at least three years on active duty after completing studies at the Army Aviation School at Fort Rucker, Alabama.

Graduate studies. Under normal circumstances, ROTC graduates may delay their active service to pursue a full-time course of instruction leading to an advanced degree. This delay status does not lengthen the active service obligation unless the degree is obtained at government expense.

Course credit. Students in the College of Arts and Science and the College of Business and Economics may subsitute military science advanced credits for six hours of electives. In the College of Engineering and Physical Sciences, six credits of advanced ROTC work are permissible within the normal program of each student, irrespective of curriculum. For curricula which include more than six hours of personal electives in the junior and senior years, inclusion of more than six hours of ROTC credit within normal programs can be effected only with the approval of academic advisers. Two credit hours may be allowed for apprentice teaching in addition to the six hours of electives aforementioned. All military science credits, including those in the basic course, apply toward the student's over-all cumulative average.

Career Opportunities

Individuals are commissioned as officers in the United States Army after completion of the ROTC program, the advanced camp, and their university degree requirements. The majority then qualify for active duty in the Army in branches (specialties) such as the Corps of Engineers, Military Intelligence, Ordinance, Finance, Field Artillery, Armor, Infantry, Medical Service Corps, or seven other major fields. Officers can work as leaders, specialists, or combinations of the two depending on the assignment.

There are opportunities for advanced military and civilian schooling beginning with a nearly three-months duration in the branch specialty. A person can also receive one alternate specialty in such areas as systems analysis, information, foreign area specilization, comptroller, or aviation. Upon graduation stu-

dents have a choice of active duty or active duty for training only (ADT). The ADT option provides the student with the opportunity to maintain the options of a military or civilian career upon completion of the program. Those individuals who receive the ADT option become officers in the Army Reserves or Army National Guard in their hometown area and essentially have a part-time military career. An officer can earn retirement through both programs after twenty years of service.

Physical facilities. Army ROTC uses areas on and adjacent to campus to conduct field training. These locations are excellent for most outdoor activities such as orienteering, patrolling, and survival training. Fort Indiantown Gap Military Reservation located east of Harrisburg Pennsylvania, is used for some field training exercises and weapons familiarization during the two annual trips there. Pennsylvania Army National Guard helicopters are normally used for aviation orientation and transportation in the fall to and from Indiantown Gap.

Programs and Opportunities

ROTC scholarship program. This program is designed to offer financial assistance to outstanding young men and women entering the ROTC program who are interested in an Army career. Each scholarship provides free tuition, textbooks and laboratory fees, in addition to pay of $100 per month for the period the scholarship is in effect. Three-, two-, and one-year scholarships are available to outstanding cadets who are currently enrolled in the four-year ROTC program and are completing either their freshman, sophomore, or junior years of college. Four-year scholarships are open to all students entering ROTC as freshman. Applications must be made to Headquarters, First ROTC Region, Fort Bragg, N.C. 28307, during the junior or senior year of high school. This may be done as early as the spring semester of the junior year, but not later than December 15 of the senior year.

Two-Year Program. Students who want to enroll in ROTC at a time after their sophomore year may apply. Applicants must successfully complete a six-week basic summer camp and have two years of undergraduate or graduate studies remaining. The student is paid for the six-week encampment and receives transportation costs to and from the camp. Individuals start in the advanced course after the basic camp.

Distinguished military graduate (DMG) program. This is a competitive program which permits outstanding ROTC students to apply for a Regular Army commission immediately upon graduation. At the end of the junior year and upon completion of the advanced summer camp, approximately one-third of each senior ROTC class may be designated as distinguished military students (DMS). A student who maintains the same high standards throughout the senior year may qualify for designation as a distinguished military graduate (DMG) and may be offered a Regular Army commission upon graduation.

Major Requirements

Individuals must either complete the two- or four-year programs, attend the advanced camp, and receive a college degree to become commissioned officers in the U.S. Army.

Course Descriptions

Leadership laboratory is conducted for all students together on Monday afternoons. The students organize, plan and run their own training. Students (primarily sophomores and juniors) are the leaders of any exercise or instructional module. Leadership and practical experience in management are developed in leadership laboratory. It also stresses working together as a team. Springtime leadership laboratories stress testing, situational analysis, and decision-making under stress during field problems test of a tactical nature. Most students of all classes have opportunities to be the leader during the latter training.

13. Basic Military Science (1) fall (usually freshman year)
Examines the purpose and organization of the Army and ROTC so that a student can see where he or she might fit. Land navigation (map reading) at a basic level is discussed. One recitation period plus an hour-and-a-half laboratory per week.

14. Basic Military Science (1) spring (usually freshman year)
Examines an introduction to tactics, military history, and instructpon in marksmanship techniques. One recitation period and two hours of leadership laboratory per week.

98. Basic Military Science (2) spring
This course is a consolidation of MS 13 and 14 into one semester.

21. Basic Military Science (2) fall (usually sophomore year).
Small-unit military tactics and operations, leadership, and the organization and functions of basic military teams. Two recitation periods and an hour and a half of leadership laboratory per week.

22. Basic Military Science (2) spring (usually sophomore year)
Land navigation (advanced). Includes special techniques in land navigation. Two recitation periods and an hour and a half of leadership laboratory per week.

105. Advanced Military Science (1) fall (usually junior year)
Examines the roles, missions and job opportunities of the various branches of the Army. It also covers the principles of military instruction. Two recitation periods and an hour and a half of leadership laboratory per week.

106. Advanced Military Science (2) spring (usually junior year)
Covers the psychological and sociological aspects of leadership and management oriented to the junior leader. Tactics at a platoon level. Three recitation periods and an hour and a half of leadership laboratory per week.

Advanced ROTC Summer Camp
This is a six-week training program conducted at Fort Bragg, N.C. Prerequisites are completion of the basic military science courses or their equivalent and MS 105 and 106. Under special circumstances and upon approval of the department chairman, this camp may be delayed until after graduation or completion of the advanced course. The summer camp experience, in coordination with respective engineering curricula, may be used to fulfill the Industrial Employment requirements of the engineering courses ChE 100, CE 100, EE 100, IE 100, ME 100, and Met 100.

107. Advanced Military Science (2) fall (usually senior year)
A study of how the military team works together via planning, organization, and coordination on both logistical and tactical means. Covers military law and military intelligence gathering. Three recitations and leadership laboratory.

108. Advanced Military Science (1) spring (usually senior year)
Considers the responsiblities of an officer on active duty, the position of the U.S. in the world, and the military implications of world change. Two recitation periods and leadership laboratory.

300. Apprentice Teaching in Military Science (2) fall-spring.
Enrollment limited to MS IV students approved by the department chairman.

Modern Foreign Languages and Literature

Professors. David W.P. Lewis, *chairman,* Dr. de l'Univ. (Modern Languages); Anna Pirscenok Herz, Ph.D. (Slavic Studies); Victor M. Valenzuela, Ph.D. (Spanish and Latin-American Studies); John A. Van Eerde, Ph.D. (Romance Languages).
Associate professors. Arthur P. Gardner, Ph.D. (German); Anje C. van der Naald, Ph.D. (Spanish); D. Alexander Waldenrath, Ph.D. (German).
Assistant professors. Linda S. Lefkowitz, Ph.D. (Spanish); Marian M. Masiuk, Ph.D. (French).
Instructor. Harriet L. Parmet, M.A. (Hebrew).

Command of foreign languages gives the student a deeper insight into his or her native tongue and opens the door to other cultures, traditions and modes of thought. Knowledge of languages is valuable in a broad range of professions. The specialist may become a translator, interpreter or teacher. Linguistic skills are useful tools in journalism, government, international relations, and increasingly in international business. A bachelor of arts degree with a major in languages can be a stepping stone to graduate school in other fields such as law, medicine and business. Finally, an ability to read foreign languages is important and often required for research in science and technology.

The department of modern foreign languages offers a balanced range of programs and courses in the following languages, literatures and cultures: French, German, Hebrew, Italian, Russian and Spanish. A modern language laboratory is available to students in these programs.

Major programs. The department offers major programs in French, German and Spanish. The candidate for the major is expected to demonstrate adequate written and oral command of the language of interest, as well as knowledge of its literature and culture.

Minor programs. The department offers minor programs in French, German, Russian and Spanish.

Related programs. These are available in Foreign Careers, Jewish Studies, Latin-American Area Studies and Russian Area Studies. Entries for these programs appear elsewhere in this section. The department participates in the following: a Foreign Careers major; an interdisciplinary major in Russian; and minor programs in Jewish, Latin-American and Russian Area Studies.

Courses in English. The department offers elective courses in English on literary, cultural and social subjects. These courses have no prerequisite and may be taken to fulfill preliminary or upper-class distribution requirements. In some cases, they are offered in conjunction with other departments.

Master of Arts in French, German and Spanish

The department offers a master of arts degree with specializations in French, German and Spanish. Students desiring to qualify for the degree should have an undergraduate major or its equivalent in French, German or Spanish. Those with undergraduate deficiencies, though otherwise qualified, may be admitted with a stipulation that they make up such deficiencies, in addition to satisfying the minimum requirements for the degree. See Section IV for requirements.

The successful completion of thirty semester-hours of courses is required for the degree. Of these thirty hours, up to twelve may be taken in a related field, particularly another foreign language. Six of these credits may be earned through a thesis rather than by taking courses for those credits. Once this option has been chosen, only the writing of a thesis can earn these six credits. A comprehensive examination covering a general knowledge of the field is required. The master of arts program is a flexible one allowing for certain options; e.g. in Spanish the student may concentrate on either Latin-American Studies or Peninsular Studies. For particulars, consult the department chairman.

Study Abroad

The department encourages students of foreign languages to spend a summer, a semester, or a full year on an approved program of study abroad. The department offers a limited number of scholarships for foreign study to qualified students. Applications should be submitted by November 1 for the spring semester and by March 1 for summer or fall.

Language opportunities on campus. The department supports language clubs. The German House is a feature of campus life and students of German are encouraged to consider residence there. (See Ger 21.)

Language placement requirement. Students are urged to take Advanced Placement or College Board Achievement Tests while still in high school. On the basis of these scores, students are placed in courses at appropriate levels. However, any student who has not had the opportunity previously must take a language test during orientation week in the fall semester.

Courses Taught in English

These Courses concerning foreign cultures and comparative topics carry no prerequisites; knowledge of the foreign languages is not required. Courses in English do not count towards a major or minor in a foreign language.

MFL 101. Opera and Literature (3)
Operas which have their origins in the Biblical, Classical and European traditions. Gardner, Van Eerde, Parmet

MFL 102. Great Foreign Cities (3)
Orgins, growth, cultural and social development of one or more of the great cities of the world.

MFL 121. Russian Literature and Culture I (3)
Customs, institutions and literary contributions to western civilization.

MFL 122. Russian Literature and Culture II (3)
Continuation of MFL 121.

MFL 141. The German Lied (3)
The intimate relationship between the music and the text of the German art-song. Gardner

MFL 142. The German Musical Theater (3)
The German opera tradition from Gluck and Mozart to Henze. Gardner

MFL 143. German Literature in Translation (3)
One period or theme in German literature. Waldenrath

MFL 151. Masterpieces of Spanish literature (3)
Reading and discussion of the most exciting works of Spanish literature.

MFL 152. Masterpieces of Latin-American Literature (3)
Reading and discussion of the most exciting works of Latin-American literature.

MFL 231. (Hist 257) France, 1715-1848 (3)
Interrelation of politics, economics, social forces, literature and culture, from Louis XIV through the Revolution of 1848. Van Eerde, Haight

MFL 232. (Hist 258) France, 1848 to the present (3)
Interrelation of politics, economics, social forces, literature and culture, since the Revolution of 1848. Van Eerde, Haight

MFL 241. Pennsylvania German Culture (3)
Cultural contribution of Pennsylavania Germans: their history, literature, art, music and politics. Waldenrath

MFL 321. Russian Realism (3)
Russian realists of the 19th century: Dostoevsky, Turgenev Tolstoy, *et al.* Lectures and class discussion in English; collateral reading and written reports in Russian or English.

MFL 322. Contemporary Soviet Literature (3)
Socialist realism in Russian literature since 1917. Lectures and class discussion in English; collateral reading and written reports in Russian or English.

French

The following courses involve use of the French language.

Preliminary courses. These may be replaced by advanced standing for students who qualify.

French 1	Elementary French (4)
French 2	Elementary French (4)
French 11	Intermediate French (3)
French 12	Intermediate French (3)

Requirements for the major. A minimum of twenty-seven credit hours is required beyond French 12, as follows:
French 51 and 52, Survey of Literature (6)
French 43 and 44, Advanced Oral and Written French (6)
Three courses from the following: French 57, 58, 245, 247, MFL 231 and 232 * (9)
Two courses at the 300-level (6)

Requirements for the departmental honors major. Thirty-three credit hours are needed. Requirements are the same as for the major, plus six additional hours of advanced literature and a 3.50 average in the major.

Recommended related courses. Students majoring in French are urged to take courses on related subjects, either within or outside the department, as approved by their adviser.

Requirements for the minor. Fifteen credit hours are required above French 12 as follows:
Four courses from any of the following: French 43, 44, 51, 52, 246, 247 (12)
One course at 200 or 300 level (3)

Requirements for advanced courses. Except where otherwise noted, 200 or 300-level courses are open to students having completed six credit hours of French beyond French 12. Exceptions require the consent of the department chairman.
*To be counted towards the major, all readings and assignments in MFL 231 and 232 must be undertaken in French.

Language of instruction. Courses are normally conducted in French.

Undergraduate Courses in French

1. Elementary French I (4) UP
Basic conversational French, illustrating essential grammatical principles, reading simple texts and writing. Language laboratory practice.

2. Elementary French II (4) UP
Continuation of French 1. Prerequisite: French 1, or appropriate Achievement Test score before entrance, or consent of the department chairman.

11. Intermediate French I (3) UP
Emphasis on readings and discussion. Prerequisite: French 2, or appropriate Achievement Test score before entrance, or consent of the department chairman.

12. Intermediate French II (3) UP
Emphasis on readings and discussion. Prerequisite: French 11, or appropriate Achievement Test score before entrance, or consent of the department chairman.

41. French Pronunciation (1) UP
Correct pronunciation of French: the obstacles commonly encountered by American speakers. Articulation, rhythm and pitch. Introduction to the International Phonetic Alphabet. Laboratory work. Prerequisite: any French course previously or concurrently. Masiuk

43. Advanced Oral and Written French I (3) fall UP
Intensive practice in oral and written French. Prerequisite: French 12, or Achievement Test score of 600, or consent of the chairman.

44. Advanced Oral and Written French II (3) spring UP
Continuation of French 43. Prerequisite: French 43 or consent of the department chairman.

46. Introduction to French for Business and Foreign Careers (3) P,UP
For students who want "vocational" French but are uncertain of their readiness for highly specialized material. Intensive revision of grammar, reading of simple contemporary texts, conversation, composition and letter writing. Prerequisite: French 11 or consent of the department chairman. Does not count towards a minor or major in French. Lewis

51. Survey of French Literature I (3) fall UP
From the Middle Ages through the 18th century. Prerequisite: French 14 or consent of chairman. Van Eerde

52. Survey of French Literature II (3) spring UP
Representative works of the 19th and 20th centuries. Prerequisite: French 51 or consent of chairman. Van Eerde

57. French Civilization I (3) UP
Development of France from prehistoric times through the 17th Century: political history, changes in social structure, literature, art. Prerequisite: French 11 or 12 or consent of the chairman.

58. French Civilization II (3) UP
Continuation of French 57 for the 18th, 19th and 20th centuries. Prerequisite: French 11, 12 or 57, or consent of the chairman.

81. French Cultural Program (1-6)
A summer program abroad. Formal instruction in the French language and direct contact with the people and their culture during at least two months in a French-speaking country.

For Advanced Undergraduates And Graduate Students

245. French for Business and Foreign Careers (3) UP
Understanding and writing French for business and international affairs; grammar review as necessary. Readings and oral presentations of current interest, with technical vocabulary (marketing, finance, industry, communications, transport, law, energy, economic relations, environment, etc.). Conducted in French. Prerequisite: French 12, 46 or consent of chairman. Lewis

247. Writing and Stylistics (3)
Practice in writing by studying the style of French authors. *Explications de texte*. Prerequisite: French 44 or 245.

269. French-Canadian Literature (3)
Literary trends and leading authors of French Canada, from 18th century to the present. Conducted in French. Lewis

270. Black Literature (3)
Major authors of French-speaking Africa and the Caribbean. Conducted in French. Lewis

271. Readings (3) UP
Study of the works of some author or group of authors, of a period, or of a literary theme. May be repeated once for credit. Prerequisite: French 12 or consent of the chairman.

303. Renaissance Poetry (3)
Study of the major poets of the period. Conducted in French. Masiuk

305. Prose in the 16th Century (3)
Analysis of fiction, memoires, historical documents, including the works of Rabelais, Montaigne, Marguerite de Navarre, Bonaventure des Périers, Jean Calvin. Masiuk

308. Symbolism (3)
Intensive study of the symbolist school of poetry, following Baudelaire through Mallarmé and the end of the 19th century. Lewis

309. Medieval French Literature (3)
Introduction to Old French from La Chanson de Roland to Francois Villon. Masiuk

311. French Classicism (3)
French classical theatre, novel and criticism, with emphasis on Corneille, Racine, Moliere, Madame de Lafayette, Malherbe and Boileau. Van Eerde

312. French Classicism (3)
Continuation of French 311. Prerequisite: French 311 or consent of the department chairman. Van Eerde

313. The Age of Enlightenment (3)
The *Philosophes* and *Encyclopedistes* of the 18th Century, with

emphasis on Voltaire, Rousseau, Montesquieu and Diderot. Van Eerde

314. The Age of Enlightenment (3)
Continuation of French 313. Conducted in French. Prerequisite: French 313 or consent of chairman. Van Eerde

317. The Romantic Movement (3)
The Romantic movement in France with readings from its principal exponents.

318. Theatre in the Twentieth Century (3)
Contemporary French drama with an analysis of its origins and movements. Lewis

323. From the Romantic Novel to the Present (3)
Representative authors, such as Stendhal, Balzac, Flaubert, Proust, Gide, Malraux, Sartre, Camus, Robbe-Grillet.

331. French Poets of the Twentieth Century (3)
Leading poets from Paul Valéry to Anne Hébert. Lewis

333. Great Women Writers of France (3)
Women writers of France from the Middle Ages to the present. Van Eerde

381. French Cultural Program (3-6)
A program in a French-speaking country offering formal language courses and cultural opportunities. Prerequisite: consent of the department chairman.

411. Voltaire (3)
Representative readings. Conducted in French. Van Eerde

412. Stendhal and Flaubert (3)
The major works of Stendhal and Flaubert with particular consideration of style, theme, and influence.

415. Proust and Gide (3)
Selected readings, with particular consideration of style, theme and influence.

416. Sartre and Camus (3)
The plays and novels of Sartre and Camus, with particular consideration of their philosophies and relation to current literary trends.

417. Moliere (3)
Moliere's most significant plays, with special reference to staging, technique and influence. Van Eerde

418. Rousseau (3)
Rousseau and pre-Romanticism. Van Eerde

420. Surrealism (3)
The contributions of Breton, Aragon, Eluard and others. Relations between painting and poetry.

422. French Satirical Literature (3)
A survey from the Middle Ages to the present.

424. Rabelais and Montaigne (3)
The principal works of Rabelais, and the Essais of Montaigne. Emphasis upon concepts of "renaissance" and "humanism." Masiuk

431. Lyric Poetry of the 12th and 13th Centuries (3)
Representative poets of the period.

432. The Roman de la Rose (3)
Intensive analysis of the romance.

433. Baudelaire (3)
Thematic and stylistic analysis of *Fleurs du Mal,* prose poems and art criticism. Lewis

491. Independent Study (1-3)
Special topics to supplement other study for the master of arts degree. May be repeated for credit.

German

Preliminary courses. These may be replaced by other courses when a student qualifies for advanced standing.

German 1	Elementary German (4)
German 2	Elementary German (4)
German 11	Intermediate German (3)
German 12	Intermediate German (3)

Requirements for the major. A minimum of twenty-seven credits beyond German 12 as follows:
German 65 Introduction to the German Literary Tradition
German 67 Conversation and Composition
German 201 Survey of German Literature I
German 241 Advanced Conversation and Composition
Five additional courses above the German 12 level, three of which must be taken as follows: German 344 *or* German 303, German 325 *or* 326, and German 305 *or* 306

Requirements for the departmental honors major.
Requirements are the same as for the major, plus: two additional advanced literature courses at the 300-level; dissertation *or* comprehensive examination (written or oral); an average of 3.50 in courses in the major.

Recommended related courses. Students majoring in German are urged to take courses on related subjects, either within or outside the department, as approved by their adviser.

Requirements for the minor. Fifteen credits above German 12 are required as follows:
German 65
German 67
three additional courses, including at least one at the 300 level.

Requirements for advanced courses. The prerequisite for all 200-level courses and above is at least one three-hour course beyond German 12 or equivalent, or consent of the chairman.

Language of instruction. Courses are normally conducted in German.

Undergraduate Courses in German

1. Elementary German I (4) spring UP
Fundamentals of German; reading of simple texts; simple conversation and composition; vocabulary building. Three class hours plus one laboratory or drill hour each week. No previous German required.

2. Elementary German II (4) fall-spring UP
Continuation of German 1, including reading of more advanced texts. Three class hours plus one laboratory or drill hour each week. Prerequisite: German 1, or two units of entrance German, or consent of the department chairman.

11. Intermediate German I (3) UP
Review of grammar; composition; reading of intermediate texts; vocabulary building. Prerequisite: German 2, or two units of entrance German, or consent of the department chairman.

12. Intermediate German II (3) UP
Continuation of German 11. Prerequisite: German 11 or consent of the department chairman.

21. German House (1) fall, spring
Supervised participation in German House activities. Pass/fail only. Grade given for participation in a prescribed minimum number of activities, upon recommendation of the faculty adviser. May be repeated for credit, but not more than three such hours may be applied toward a major in German. Gardner

63. Introduction to German Culture (3)
Lectures, readings and discussion of selected aspects of German culture. Prerequisite: German 12 or equivalent, or consent of the department chairman.

65. Introduction to the German Literary Tradition (3) UP
Representative works from one or more of the major periods of

German literature. Prerequisite: German 12 or equivalent, or consent of the department chairman.

67. Conversation and Composition (3) UP
Intensive practice in oral and written German. Prerequisite: German 12.

For Advanced Undergraduates And Graduate Students

201. Survey of German Literature I (3) fall UP
German literature to the second half of the 18th Century. Readings, lectures and discussion of representative works.

202. Survey of German Literature II (3) spring UP
From the Age of Goethe to the present. Readings, lectures and discussion of representative works.

211. Introduction to German Drama (3) UP
Drama as a literary genre; plays from various periods of German Literature. Gardner

213. Introduction to the German Lyric (3) UP
The lyric as a literary genre: representative poets from various periods. Gardner

214. Goethe's "Faust" (3) UP
Study of Goethe's play with an introduction to the Faust tradition.

241. Advanced Composition and Conversation (3)
Conducted in German.

250. Special Topics (1-3)
Literary and linguistic topics not covered in regular courses. May be repeated once for credit.

301. Middle High German (3)
Introduction to the language; lectures and readings in medieval literature. Gardner

303. German Romanticism (3)
Early and late Romanticists. Waldenrath

305. 20th-Century German Literature I (3) fall
Representative writers from Naturalism to Expressionism. Gardner

306. 20th-Century German Literature II (3)
Representative writers from Expressionism to the present.

307. German Renaissance, Baroque and Enlightenment (3)
Writers and literary movements from the end of the Middle Ages to the middle of the 18th century.

325. 19th-Century German Literature I (3)
Representative writers from Eichendorff to the Biedermeier. Gardner

326. 19th-Century German Literature II (3)
Representative writers from the Biedermeier to Naturalism. Gardner

341. Advanced Composition (3)
Essay writing and translation from and into German.

341. The Age of Goethe (3)
Selected works from Klopstock to Hölderlin, with special emphasis on Herder, Goethe and Schiller. Waldenrath

350. Special Topics (1-3)
Literary or linguistic topics not covered in regular courses. May be repeated once for credit.

421. Renaissance and Baroque Literature (3)
German literature from *Der Ackermann aus Böhmen* to the Age of Enlightenment.

432. Lessing and the Enlightenment (3)
Discussion and analysis of literature in the pre-classical age. Waldenrath

451. Nineteenth-Century German Lyric Poets (3)
Study of lyric poetry from Heine through C.F. Meyer. Gardner

452. Twentieth-Century German Lyric Poets (3)
Study of lyric poetry from Nietzsche and Liliencron through the Expressionists. Gardner

471. Independent Study (3)
Study of an author or area of German literature. May be repeated once for credit.

Hebrew

1. Elementary Modern Hebrew I (3) UP
Classroom and laboratory instruction geared to the development of hearing, speaking, reading and writing the language. Cultural, ethnic and religious dimensions of Israeli society. Tapes, textual materials, short stories. No previous study of Hebrew required. Parmet

2. Elementary Modern Hebrew II (3) UP
Continuation of Hebrew 1 utilizing the audio-lingual approach. Fundamentals of the language, structure and sounds; the Hebrew verb; reading of vocalized stories; written exercises; tapes; short stories. Prerequisite: Hebrew 1 or its equivalent. Parmet

11. Intermediate Modern Hebrew I (3) UP
Classroom and laboratory instruction to develop fundamental patterns of conversation and grammar; composition, reading of texts, laboratory work and sight reading; comprehension, speaking, reading and writing of unvocalized materials. Prerequisite: Hebrew 2 or qualifying examination. Parmet

12. Intermediate Modern Hebrew II (3) UP
Continuation of Hebrew 11. Reading of texts, including selected short stories, outside reading and supplementary material; increased emphasis on oral presentation. Prerequisite: Hebrew 11 or approval of the department chairman. Parmet

Italian

1. Elementary Italian I (3) fall, alternate years UP
Grammar, composition; rapid reading of easy modern prose. No previous study of Italian required. Van Eerde

2. Elementary Italian II (3) spring, alternative years UP
Continuation of Italian I. Prerequisite: Italian I or consent of the department chairman. Van Eerde

11. Intermediate Italian I (3)UP
Review of grammar by reading literature. Development of speaking, with some attention to writing in compositions pertaining to daily experience. Prerequisite: Italian 2. Van Eerde

12. Intermediate Italian II (3) UP
Continuation of intermediate Italian 1.

Russian

Requirements for the minor. Eighteen credit hours of Russian are required not including MFL 321 and 322.

1. Elementary Russian I (3) fall UP
Classroom and laboratory introduction to the fundamentals of conversational and grammatical patterns; practice in pronunciation, simple conversation, reading and writing.

2. Elementary Russian II (3) spring UP
Continuation of Russian 1. Prerequisite: Russian 1 or two units of entrance Russian.

11. Intermediate Russian I (3) fall UP
Classroom and laboratory practice in conversation. Development of reading and writing skills. Prerequisite: Russian 2 or three units of entrance Russian, or consent of the department chairman.

12. Intermediate Russian II (3) spring UP
Continuation of Russian 11. Prerequisite: Russian 2 or 11, or three units of entrance Russian, or consent of the department chairman.

31. Russian in Science, Economics, and Industry I (3) fall UP
Readings and conversations about nonliterary topics including the social and natural sciences, business, economics and industry. Prerequisite: Russian 12 or consent of the department chairman.

32. Russian in Science, Economics, and Industry II (3) spring UP
Continuation of Russian 31. Prerequisite: Russian 12 or 31, or consent of the department chairman.

41. Conversation and Composition I (3) fall UP
Intensive practice in oral and written Russian; laboratory practice in aural comprehension. Readings and discussions on Russian literature and culture. Prerequisite: Russian 12, or three units of entrance Russian, or consent of the department chairman.

42. Conversation and Composition II (3) spring UP
Continuation of Russian 41. Prerequisite: Russian 41 or consent of the department chairman.

251. Special Topics (3) UP
Intensive study of literary or linguistic topics. Prerequisite: Russian 42, or consent of the department chairman. May be repeated once for credit.

252. Special Topics (3) UP
Continuation of Russian 251. May be repeated once for credit.

Spanish

Preliminary courses. These may be replaced by other courses if students achieve advanced standing.

Span 1	Elementary Spanish (4)
Span 2	Elementary Spanish (4)
Span 11	Intermediate Spanish (3)
Span 12	Intermediate Spanish (3)

Requirements for the major. A total of twenty-seven credit hours are required above Span 12 as follows: Span 141; Span 142; Span 151; Span 152.
Five courses at the 300 level at least two courses must be selected from Peninsular literature and at least two from Latin-American literature.

Requirements for departmental honors major. Thirty-three credit hours are required above Span 12 as follows: twenty-seven credits, as for the major; six additional hours of advanced courses; a 3.50 average in the major.

Requirements for the minor. Fifteen credits are required above Span 12, including: at least one of the following: Span 13, 142, 355; Span 141; at least one course in literature.
Students majoring in Spanish are urged to take courses on related subjects either inside or outside the department, as approved by their adviser.

Requirement for advanced courses. The normal prerequisite for 200- and 300-level courses in Spanish is Span 151 and/or 152. Exceptions require consent of the department chairman.

Language of instruction. Courses are normally conducted in Spanish.

Undergraduate Courses in Spanish

1. Elementary Spanish I (4) UP
Basic conversational Spanish illustrating essential grammatical principles, reading of simple texts and writing.

2. Elementary Spanish II (4) UP
Continuation of Span 1. Prerequisite: Span 1.

11. Intermediate Spanish I (3) fall
Thorough review of grammar, practice in speaking and writing, using materials of contemporary interest. Prerequisite: Span 2.

12. Intermediate Spanish II (3) spring UP
Continuation of Span 11. Thorough review of grammar. Emphasis on readings and discussion. Prerequisite: Span 11.

13. Development of Language Skills (3) UP
For the student who wants to improve oral proficiency; discussion of contemporary themes. Prerequisite: Span 12.

131. Communicating in Spanish for Medical Personnel (1) UP
For prospective medical personnel who will be communicating with Spanish-speaking patients. Practical dialogues. Acquisition of essential vocabulary covering aspects of health care. Grammar review provided when necessary. Prerequisite: one year of college or two years of high school Spanish. This course is not available for credit towards a major or minor in Spanish. Lefkowitz

133. Phonetics and Pronunciation (3) UP
Comparison of Spanish and English sounds, descriptions of Spanish vowels and consonants in their various positions. Abundant oral practice and special emphasis on accent and intonation patterns. Exercises in phonetic transcription, employing the international phonetic alphabet. Prerequisite: Span 12. Lefkowitz

141. Advanced Grammar and Composition (3) fall UP
Intensive review of Spanish grammar with stress on finer points. Analysis of syntax and style. Prerequisite: Span 12.

142. Advanced Conversational Spanish (3) spring UP
Conversational practice stressing the building of vocabulary, based on literary texts and topics of general interest. Designed to stimulate fluent and spontaneous use of spoken Spanish. Prerequisite: Span 12.

151. Cultural Evolution of Spain (3) fall UP
The historical and cultural evolution of Spain from its beginning to the present. Prerequisite: Span 12. Lefkowitz or van der Naald

152. Cultural Evolution of Latin America (3) spring UP
The historical and cultural evolution of Latin America. Prerequisite: Span 151. Valenzuela

162. Women Writers of Latin America (3) spring UP
The contribution of women writers to Latin-America literature. Prerequisite: Span 152. Valenzuela

For Advanced Undergraduates And Graduate Students

211. Practical and Business Spanish (3)
For students with a basic knowledge of Spanish: use of the language in business, law, international and social relations. Letter-writing, comprehension of technical texts, newspapers, acquisition of a specialized vocabulary in the individual's professional field. Grammar review when necessary. Prerequisite: two year of college Spanish or four years of high school Spanish. This course is not available for credit towards a major or minor in Spanish. Lefkowitz

213. Performing Spanish Theatre (1-3)
Preparation of a play and performance before an audience. Conducted entirely in Spanish. Prerequisite: one course beyond Span 12 and consent of the department chairman.

271. Independent Study (3)
Study of an author or group of authors or of a period. Prerequisite: consent of the chairman. May be repeated once for credit.

281. Spanish Cultural Program (1-6)
A summer program abroad. Formal instruction in Spanish grammar, conversation and culture during one or two months in Spain or Latin America on an approved program.

301. The Spanish Essay (3)
Reading and discussion of outstanding thinkers from the 18th century to the present. Prerequisite: Span 151 or consent of the department chairman. van der Naald

302. The Latin-American Essay (3)
Reading and discussion of distinguished Spanish-American essayists of the 20th Century with emphasis on the works of Rodo, Vasconcelos Vaz Ferreira, and Francisco Romero. Oral and written reports. Prerequisite: Span 152. Valenzuela

303. Don Quijote (3)
Reading and critical analysis. Prerequisite: Span 151. Lefkowitz

305. Spanish Literature of the Middle Ages (3)
Reading and discussion of outstanding works such as *El Cid, El Libro de Buen Amor* and *La Celestina.* Topics vary. Prerequisite: Span 151. Lefkowitz

306. Existentialism and the Latin-American Novel (3)
Reading and discussion of representative works of contemporary Latin-American novelists. Prerequisite: Span 152. Valenzuela

308. Peninsular Literature Since 1939 (3)
Reading and discussion of representative contemporary Spanish poets, playwrights and novelists. Prerequisites: Span 151 or consent of the chairman. van der Naald

310. Literature of 19th-Century Spain (3)
Poetry, novels and plays that exemplify the literary movements of Romanticism, Realism and Naturalism. Topics vary. Prerequisite: Span 151 or consent of chairman. van der Naald

315. Nineteenth-Century Spanish Theater (3)
Prerequisite: Span 151. van der Naald

317. Twentieth-Century Spanish Theater (3)
Prerequisite: Span 151. van der Naald

331. Spanish-American Literature (3)
Literature of the pre-Columbian, conquest and colonial periods. Oral and written reports. Conducted in Spanish. Prerequisite: Span 152. Valenzuela

333. The Novel of the Mexican Revolution (3)
Reading and discussion of representative novels. Prerequisite: Span 152. Valenzuela

334. Drama in Latin America (3)
Reading and discussion of representative plays of the 19th and 20th centuries. Prerequisite: Span 152.

350. Special Topics (1-3)
Study of literary and linguistic topics not covered in regular courses. May be repeated once for credit.

351. Fifteenth-Seventeenth Century Peninsular Literature (3)
Historical, cultural and literary analysis of prose and poetry. Topics vary. Prerequisite: Span 151. Lefkowitz

353. Development of the Novel in Spain (3)
Caballeresque, Picaresque, Sentimental, Moorish and Pastoral novels from the 14th to the 17th century. Topics vary. Prerequisite: Span 151.

355. Improvisational Theater Games in Spanish (3)
For students who have some fluency in the language and who wish to practice and improve their oral Spanish in a creative setting. Enrollment limited to 14. Prerequisite: third-year level fluency. van der Naald

357. Women Novelists and Playwrights of Latin America (3)
Reading and discussion of outstanding contemporary works by Latin American women. Prerequisite: Span 152. Valenzuela

361. Gaucho Literature (3)
Reading and discussion of representative works such as *Facundo, Marin Fierro* and *Don Segundo Sombra.* Prerequisite: Span 152. Valenzuela

363. The Latin-American Short Story (3)
Reading and discussion of outstanding Latin-American short story writers. Prerequisite: Span 152. Valenzuela

412. Neruda and Mistral (3)
Study of representative works. Prerequisite: a 300-level course. Valenzuela

413. Ruben Dario (3)
Study of the poetry of Ruben Dario and his relation to the *Modernismo* movement. Prerequisite: a 300-level course. Valenzuela

416. Spanish Drama of the 17th Century (3)
The development of the Spanish drama of the Golden Age. Prerequisite: a 300-level course. van der Naald

418. Seminar on Borges and Cortazar (3)
The life and works of Jorge L. Borges and Julio Cortazar. Prerequisite: a 300-level course. Valenzuela

423. The Literature of Puerto Rico (3)
Reading and discussion of representative writers. Prerequisite: a 300-level course. Valenzuela

481. Literature of the Spanish Middle Ages and Golden Age (3)
Topics vary. Prerequisite: a 300-level course. Lefkowitz

491. Independent Study (3)
Special topics to supplement other study for the master of arts degree. Prerequisite: consent of the department chairman. May be repeated once for credit.

Modern Hebrew

See Modern Foreign Languages, which proceeds this cross reference.

Music

Professor. Robert B. Cutler, M.A., *chairman.*
Assistant professors. Jerry T. Bidlack, M.A.; James E. Brown, M.A.
Instructor. Kathryn Louise Reichard, A.M.

The department of music offers instruction in music history, theory and performance. With the approval of the department, a student may major or minor in music.

Major program. A total of twenty-four credit hours beyond Mus 81. Normally Mus 222 and 224 must be elected. Mus 20 may not be counted toward the major.

Minor program. A total of fifteen credit hours are required which may include Mus 20 and 81.

Courses in the series Mus 21-78 may not be counted toward either the major or the minor.

Admission to the band, choruses, ensembles and orchestra is by audition, and students receive credit by registering for the appropriate course in the series Music 21-68. Although there is no limit to the number of courses in this series which a student may take, students should check carefully with their advisers to determine the value of the courses as graduation credit. For example, a maximum of eight credits may be applied toward graduation in the College of Arts and Science. None of these apply toward the college humanities distribution requirement.

Private lessons may be arranged through the music department at set fees. The cost of lessons is not included in tuition.

Concert Series

Music at Lehigh is a series of free professional concerts sponsored by the department. This series of concerts is administered by a committee of students and faculty members of the department. Among the artists heard are the Goldovsky Opera Company, the Philadelphia Composers Forum, the Cincinnati Early Music Consort, the Mostovoy Soloists and the Nu Liberation Art Unit. In addition to this series, there are frequent concerts by Lehigh's own choral and instrumental performing groups.

Course Offerings in Music

20. Introduction to Musical Literature (3) UP fall-spring
Musical style approached through representative works from the Middle Ages to the present. Open neither to students who have taken Mus 81 or equivalent, nor to music majors.

21-28. Band (1)
31-38. Chamber Singers (1)
41-48. Ensembles (1)
51-58. Glee Club (1)
61-68. Orchestra (1)
71-78. Private Study (1)

Private instrumental or vocal study with instructors who are approved by the department. Prerequisite: consent of department chairman.

81. Theory I: Fundamentals (3) UP fall-spring
Introduction to rhythm, pitch and timbre; melody, counterpoint and harmony; analysis, composition, ear training, keyboard harmony, and sight singing. Prerequisite: consent of the department chairman.

121. Theory II (3) UP fall-spring
Exercises in counterpoint and harmony. Ear training, keyboard harmony, sight singing, and analysis. Prerequisite: Mus 81 or equivalent.

123. Theory III (3) U fall
Tonal forms and procedures. Writing of four compositions based on models. Ear training, keyboard harmony, sight singing, and analysis. Prerequisite: Mus 121.

131. Major Genres (3) UP fall
Evolution of a single kind of musical composition. Title varies: opera, symphony, etc. May be repeated for credit as title varies. Prerequisite: Mus 20 or 81.

132. Composer and Era (3) UP spring
Life and develoment of one composer's musical style viewed in historical context. Some attention to works of contemporaries. Title varies: J.S. Bach, Mozart, etc. May be repeated for credit as title varies. Prerequisite: Mus 20 or 81.

133. Music of the Middle Ages and the Renaissance (3) UP fall, odd-numbered years
Sacred and secular compositions (vocal and instrumental) from early Christian chant through the madrigal, Mass, and motet of the late sixteenth Century, viewed in cultural contexts. Prerequisite: Mus 20 or 81.

135. Music of the Twentieth Century (3) UP fall, 1980
Analysis of selected works from Debussy to the present; particular attention to post-romanticism, Stravinsky, serialism, electronic music, and the music aesthetic of John Cage. Prerequisite: Mus 20 or 81. Brown

153. Electronic Music (3) UP fall
Components of an electronic studio introduced via a working relationship. Properly recording both live and electronic sounds, realizing a portion of score for electronic sound, constructing tape loops having particular characteristics, and preparing a final work of taped sounds. Prerequisite: consent of the department chairman. Brown

154. Electronic Music (3) UP spring
Continuation of Mus 153. Prerequisites: Mus 153 or equivalent and consent of the department chairman. Brown

220. Composition (3) U spring
Applications of the principles of Mus 81 and 121 to compositional practice. Prerequisites: Mus 121 or equivalent and consent of the department chairman. Brown

222. Survey of Western Art Music (3) U spring, 1979, '81
Systematic, chronological study of major styles and concepts of music from antiquity to the present. Prerequisite: Mus 121 and three hours at the 100 level. Reichard

224. Theory IV (3) U spring, even-numbered years
Advanced harmonic and contrapuntal techniques applied primarily to a chromatic idiom. Ear training, keyboard harmony, sight singing, and analysis. Prerequisite: Mus 123.

251. Special Topics (1-3) U
Topics or work in composition not otherwise covered, or continuation of topics or work in composition begun in courses. May be repeated for credit. Prerequisite: consent of the department chairman.

Natural Science

J. Donald Ryan, Ph.D., *director*, natural science program

This major provides students with a broad background in the fundamentals of mathematics and science and the opportunity to concentate to a reasonable degree in one area of science.

The program is designed especially for the following: 1. those students who want preparation for graduate work or careers in certain of the derivative or interdisciplinary sciences or realted professional fields (oceanography, astronomy, psychophysiology, computing and information science, medicine or dentistry, etc.), 2. those students who plan to teach in secondary schools or community colleges, and 3. those students without fixed career objectives who want undergraduate training in science.

Students who register for the program are required to select an area of concentration (or option) which must be approved by the dean of the College of Arts and Science and the director of the program. The option may be chosen in chemistry, biology, geology, psychology, or in an approved interdisciplinary area biophysics, marine science, biochemistry, computing and information science, etc.). Courses included in the option are worked out individually for the student by the major adviser.

A special program leading to a bachelor of arts in natural science and a master of science in materials is available for interested students. See Five-Year Programs.

Qualified students may be given permission at the end of the junior year to enter a program whereby they are able to begin work toward a graduate degree (Master of Arts, Master of Science, or Master of Education) during the senior year. Students enrolled in this program often complete all requirements for the master's degree with one year of study beyond the bachelor degree.

required preliminary courses

Math 21,22,23	Analytical Geometry and Calculus (12)
Phys 11, 12	Introductory Physics I and Laboratory (5)
Phys 21, 22	Introduction Physics II and Laboratory (5) *or*
Phys 13, 14	General Physics (4)
Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
Geol 1, 2	Principles of Geology (4) *or*
Astron 1	The Solar System (3)
Biol 21, 22	Principles of Biology (4) *or*
Psych 3	Psychology As a Natural Science (3)

required major courses

Chem 51, 52, 53, 54	Organic Chemistry *or*
Chem 31	Chemical Equilibria in Aqueous Systems (3)
Chem 187	Physical Chemistry (3)
Math	elective (3)
	option (24)

Note: The mathematics elective and courses included in the option are taken with approval of the major adviser.

Students registered for this major normally are expected to choose their option no later than the second semester of the sophomore year.

Philosophy

Professors. Robert F. Barnes, Jr., Ph.D.; Stephen L. Goldman, Ph.D.; Thomas M. Haynes, Ph.D.; Norman P. Melchert, Ph.D.
Associate professor. J. Ralph Lindgren. Ph.D., *chairman.*
Assistant professors. John E. Hare, Ph.D.; Adele E. Laslie, Ph.D.

Students considering extensive study in philosophy, whether as a major, a major in conjunction with a minor in another field, or as a minor, need answers to two main questions: What is the field of philosophy like? And what career possibilities are there for someone who majors or minors in philosophy?

Philosophically inclined thinkers have always asked fundamental questions about the intellectual, moral, religious, social, and political aspects of human life. They have tried to subject these issues to rigorous analysis and provide thoughtful answers relevant to their time. The major current contexts for philosophical inquiry are the nature and place of moral values in contemporary life, the dysfunction of social and political institutions, the impact of technology, and the challenge of the scientific world view.

These lead to such questions as: What is the relation of the individual to the state and its laws? Which human lifestyles and institutions are conceptually viable in a technological society? What are the implications of the scientific world picture for our concepts of religion, freedom, and creativity? The analysis of the component issues in these and many more problems, the unearthing of presuppositions, the proposal of answers, and the critique of those proposals are the actual elements of philosophical investigation.

The study of philosophy provides preparation for a variety of careers either immediately after graduation or after further study beyond the bachelor degree. Careers requiring further study for which philosophy is an especially suitable preparation include: academic philosophy; law; some types of government service, e.g., urban planning; certain careers in business, e.g., management consulting, personnel and industrial relations; the ministry; academic careers in areas other than philosophy, e.g., intellectual history, religion studies, social and political theory, and information systems; and primary and secondary education.

Students majoring or minoring in philosophy who are not considering such fields find a wide variety of careers open to them after graduation. Capable philosophy students who choose their electives wisely find that the analytical, logical and discursive skills provided by philosopical training enable them to successfully pursue careers after graduation in such fields as communications, publishing, insurance, marketing, merchandising, social services, advertising, transportation and utilities.

The curriculum of both the major and the minor in philosophy provides both ample flexibility for tailoring course work in philosophy to the developing interests of each student and wide latitude for supplementing these studies with work in other disciplines. The aim of these curricula is to enable each student, working closely with the departmental adviser, to develop a total curriculum in the light of individual interests and aspirations.

The minor in philosophy consists of fifteen hours of course work. The specific courses to be taken by a student in this program are decided jointly by the student and the departmental adviser. These ordinarily include at least one course at the introductory level and one at the advanced level. Minor programs may be either of a general character or organized around a special theme such as: the philosophy of science, logic, ethics and value theory, the history of philosophy, and social philosophy.

The Major Program

The major in philosophy consists of thirty hours of course work. Again, the specific courses to be taken by each student are decided jointly by the student and the departmental adviser. In the case of the major, the following minimum constraints are observed: required courses are as follows:

Phil 14	Foundations of Logic (3)
Phil 15	Ethics (3)

plus three of the following

Phil 131	Ancient Philosophy (3)
Phil 133	Medieval Philosophy (3)
Phil 135	Modern Philosphy (3)
Phil 139	Contemporary Philosophy (3)

An additional fifteen hours is selected with the counsel and approval of the adviser. At least nine of these fifteen hours are at the 200 level or above. Normally these will be courses in the philosophy curriculum, although substitutions of courses from other departments may be made with the approval of the adviser. Phil 221 does not count toward the major. Not more than two of the following count toward the major: Phil 1, Phil 2, Phil 10. At the discretion of the department, a major may be required to take and pass Engl 71, Expository Writing Workshop.

Undergraduate Courses

1. Socrates to Bacon (3) P fall-spring
The ideas of the great philosophers in our tradition from early times through the Middle Ages. The problems they addressed, the solutions they proposed, and how they shaped our heritage. Melchert

2. Descartes to Sarte (3)P spring
The ideas of the great philosphers in our tradition from the Renaissance to recent times. The problems they addressed, the solutions they propsed, and how they shaped our heritage. May be taken independently of Phil. 1. Melchert

10. Introduction to Philosophy (3) P fall-spring
Basic philosophical questions, perennial and contemporary, such as the objectivity of morals, the justification of government, the place of mind and feeling in the world of matter and energy, the nature of knowledge and truth, and the reality of God.

13. Practical Logic (3) P fall
Reaching conclusions and justifying conclusions—two kinds of reasoning. The role of logic in problem solving and decision-making processes. Comparison of deductive and inductive reasoning and justification. Practice in analysis, criticism, evaluation and construction of arguments. Emphasis on developing practical ability, with material drawn from real-life contexts. Barnes

14. Foundations of Logic (3) UP spring
The development of several symbolic languages as theroretical models for explaining certain logical features of ordinary English discourse, such as valid inference and necessary truth. Some significant general properties of these symbolic languages are studied. Barnes

15. Ethics (3)P fall-spring
Development of the ability to thoughtfully formulate one's own moral orientation and to understand those of others through a critical study of major ethical theories such as rationalism, formalism, utilitarianism, and existentialism. Special attention is directed to such topics as moral character, judgment and responsibility. Haynes

42. The Scientific Process (3) P spring
Study of the generation and acceptance of scientific concepts and laws, especially the contributions of theory, metaphysics, and value. Case studies in the history of science illustrate the logic of this intellectual activity. Laslie

75. (Psych 75) Behavior Control and Human Values (3) P fall
Philosophial examination of operant conditioning techniques for controlling behavior. Value problems related to autonomy of individual choice, responsibility, rationality, freedom and dignity, and punishment. To what end shall behavior be controlled, and who will control the controllers. Prerequisite: an introductory course in either psychology or philosophy, or consent of the department chairperson. Melchert, Brody

100. Philosophy of Contemporary Civilization (3) UP fall-spring
Analysis of philosophical issues encountered in public and private decision making. Evaluation of the various techniques used in describing and prescribing alternate plausible ideals and structures for major act-forms and institutions (family, work,

education, science, art, recreation, law, politics and religion). Haynes

116. Medical Ethics (3) spring
Contemporary moral problems encountered in the practice of medicine examined in the light of ethical theories of the nature and foundation of rights and moral obligations. Abortion, euthanasia, genetic engineering, the nature of informed consent, the distribution of health care, etc. Hare

122. Philosophy of Law (3) spring
Selected features of legal institutions, including their nature and functions, sources of law, the constraints of justice and morality, and the logic of judicial reasoning. Special attention is devoted to selected conceptual difficulities in the criminal law, including responsibility and punishment; to various modes of citizen participation in and control over legal institutions including the jury system and civil disobedience. Lindgren

123. Aesthetics (3) fall
Theories, classical and modern, of the nature of beauty and the aesthetic experience. Practical criticism of some works of art, and examination of analogies between arts, and between art and nature. Hare

124. (RS 124) Reason and Religious Experience (3) spring
A critical look at some of the fundamental problems of religion: the nature of religious experience and belief, reason and revelation, the existence and nature of God, the problem of evil, and religious truth. Hare

126. Philosophical Issues in Feminism (3) spring
Feminist social and political theories: freedom, equality, and justice, and their relevance in evaluating the positions of women and men in society. Leslie

131. Ancient Philosophy (3) fall
Historical study of philosophy in the classical world from the pre-Socratics to Plato, Aristotle, and the Neo-Platonists, as the originators of the western tradition in philosophy and as interacting with the religious, political and scientific life of their times. Hare

133. Medieval Philosophy (3) spring 1980
Historical study of philosophy from the fall of the Roman Empire to the Renaissance. Attention to Islamic, Jewish and Christian traditions and their interaction with the scientific and cultural life of the period. Hare

135. Modern Philosophy (3) spring 1981
Philosophers from the Renaissance to the mid-19th Century. Descartes, Locke, Hume, Rousseau, Kant and Hegel. Their interaction with political, scientific, and religious thought of the period. Lindgren

139. Contemporary Philosophy (3) spring
Philosophical thought from the mid-19th Century to the present: pragmatism, linguistic analysis, existentialism, and Marxism. Truth and knowledge, values and moral judgment, meaning, and place of the individual in the physical world and society, and the impact of scientific method upon all of these. Melchert

143. (RS 143) Kierkegaard (1) spring
An introduction to the life and thought of Kierkegaard, the 19th-Century Danish forerunner of existentialism, with a brief look at his impact on philosophy, theology, psychology and literature. Melchert

144. Karl Marx (1) fall
Introduction to the life and writings of Karl Marx, with special attention to his analyses of alienation, capitalism, history, revolution, and the Communist movement. Lindgren

150. (Engl 150) Media and Values (3) fall 1979
How media and values are formed and reformed by their mutual interaction. Combines humanistic criticism with philosophical analysis to study a considerable range of the principal media (the human body, language, film, television, architecture, art) through which human values arise and take their place in the world. Historical, existentialist, phenomenological, and structuralist analyses are stressed. Individual student projects in media-value analysis or manipulation are required. Haynes, DeBellis

161. Science, Philosophy, and Religion (3)
Influence of philosophic thought and religious belief on Newtonian science from its emergence in the 17th Century to its decline in the 20th Century. Goldman

For Advanced Undergraduates and Graduate Students

221. (Law 221) Sex-Discrimination and the Law (3) fall
A critical study of the law of sex-discrimination in areas of constitutional and labor law. A case approach which places special emphasis on the rights of employees and the obligations of employers. Topics include equal protection, equal employment opportunity, and affirmative action. Lindgren

261. Introduction to Philosophy of Science (3) fall
Analysis of the structure and foundations of scientific knowledge. Topics such as explanation, empirical significance, operationalism, theory and observation, confirmation, and induction are investigated. Laslie

264. Meaning (3) spring 1980
Investigation of the problem of how language, a conventional and arbitrary structure of symbols, can be a vehicle of meaning. Theories of meaning, such as referential, picture, behavioristic, and speech act theories are discussed. Laslie

267. Philosophical Games (3)
Seminar on philosophical problems in the theory of games. Identification and evaluation of the merits and difficulties of both competitive and noncompetitive games. Student participation in games. Laslie

271. Readings in Philosophy (1-3)
A course in readings designed primarily for undergraduate philosophy majors and minors and graduate students in other disciplines. Prerequisite: consent of the department chairperson.

272. Readings in Philosophy (1-3)
A course of readings designed primarily for undergraduate philosophy majors and minors and graduate students in other disciplines. Prerequisite: consent of the department chairperson.

301. Philosophy of the Social Sciences (3) spring 1980
An analysis of the social sciences considered as programs for achieving understanding and control of man and society. Study is made of assumptions basic to, and problems incurred in, scientific methodology in general; the implications of these for the various social sciences are stressed. Haynes

314. Logical Theory (3) spring 1981
Conceptual foundations and philosophical significance of classical and modern logical theories. Analysis of the syntactic and semantic methods in logic, and their interrelations. Philosophical impact of important technical results, including Goedel's incompleteness theorem. Some discussion of potential future developments and alternative logics. Prerequisite: Phil 14 or consent of the department chairperson. Barnes

315. Contemporary Ethics (3) spring 1981
Recent literature on some ethical theories and metaetical problems. Subsequent examination of selected substantive issues such as: ecological ethics: strategies and factors in moral education; mythic frameworks of various moralities; relation of ehtics to social sciences and to practices in economics, law, religion. Prerequisite: Phil 15 or consent of the department chairman. Haynes

350. Minds and Bodies (3) spring 1980
Investigation of consciousness in the light of what is known about brains and behavior. The nature and status of sensations, thinking, intentional actions, free choice, and the self are discussed. Melchert

391. Advanced Topics in Philosophy (1-3)
Examination of selected topics for philosophy majors and minors and other advanced students. Prerequisite: consent of the department chairman.

Physics

Professors. W. Beall Fowler, Ph.D., *chairman;* Garold J. Borse, Ph.D.; Raymond J. Emrich, Ph.D.; Frank J. Feigl, Ph.D.; Robert T. Folk, Ph.D.; Alvin S. Kanofsky, Ph.D.; Yong W. Kim, Ph.D.; James A. McLennan, Ph.D.; Shelden H. Radin, Ph.D.; Wesley R. Smith, Ph.D.; Wesley J. Van Sciver, Ph.D.; George D. Watkins, Ph.D., Sherman Fairchild professor of solid-state studies.
Associate professors. Brent W. Benson, Ph.D.; Ernest E. Bergmann, Ph.D.; Jeffrey A. Sands, Ph.D.; Russell A. Shaffer, Ph.D.; Donald B. Wheeler, Jr., Ph.D.

Students may major in physics by means of the curriculum of engineering physics in the College of Engineering and Physical Sciences or by means of the physics major in the bachelor of arts curriculum in the College of Arts and Science. The physics contents of the two curricula are similar. The requirements differ mainly in the required distribution courses. A comparison of the two curricula in terms of credit hours in various broad categories is given below.

	engineering physics	B.A. major in physics
Freshman English	6	6
distribution courses (not including mathematics or science)	19	32
required preliminary and major courses	63	63
approved electives	14	8
electives	20 to 26	11
total	122 to 128	120

A student in physics studies the basic laws of mechanics, heat and thermodynamics, electricity and magnetism, optics, relativity, quantum mechanics, and elementary particles. The student also studies applications of the basic theories to the description of bulk matter, including the mechanical, electric, magnetic and thermal properties of solids, liquids, gases, and plasmas, and to the description of the structure of atoms and nuclei. In addition, the student develops the laboratory skills and techniques of the experimental physicist, skills which can be applied in the experimental search for new knowledge or in applications of the known theories.

Because of the fundamental nature of physics and because of the flexibility in the choice of electives, physics students may use the major to prepare for many different careers. The basic program can prepare the student for graduate work in physics or, with appropriate choices of electives, in applied mathematics, in science or in allied sciences such as biophysics, molecular biology, astrophysics, geophysics, chemical physics, materials meteorology, or physical oceanography.

In addition, the student may choose electives so as to prepare for graduate work in those areas of engineering which have a high science content, such as aeronautical engineering; nuclear engineering, including both fission and fusion devices; electrical engineering, including electronics and solid-state devices, electrical discharges and other plasma-related areas; mechanical engineering and mechanics, including fluids and continuum mechanics. Graduate work in any of these areas can prepare the student for a career in industrial research or development, or in university or college teaching and research.

The student who plans on employment immediately after the bachelor's degree may choose electives available so as to develop the particular skills needed for a position in a particular area. For example, with judicious choices of electrical engineering and physics courses in electronics, transistors, and solid-state physics, a strong applied background can be developed for employment in solid-state electronics. If the student chooses applied mathematics courses and computer courses to supplement the physics course, a strong preparation can be achieved for employment in the many areas which use numerical methods in analysis and development.

Many other specialties may be developed by the student by appropriate use of electives so that the bachelor-degree student can offer an employer the advantages of a broad and fundamental science background combined with a significant concentration in a particular area of science, engineering, or applied mathematics.

Students are advised that admission to graduate school requires a minimum grade average, with a minimum average of B being typical. Also some graduate schools require a reading knowledge of a modern foreign language.

Physics Major in Arts and Science

required preliminary courses

Chem 21,22	Principles of Chemistry (5)
Math 21,22,23	Analytical Geometry and Calculus (12)
Phys 11, 12	Introductory Physics I and Laboratory (5)
Phys 21,22	Introductory Physics II and Laboratory (5)

required major courses

Phys 31	Introduction to Quantum Mechanics (3)
Phys 90	Electrical Phenomena (1)
Phys 171	Proseminar (1)
Phys 191	Laboratory Techniques (2)
Phys 212	Electricity and Magnetism I (3)
Phys 213	Electricity and Magnetism II (3)
Phys 215	Particles and Fields I (3)
Phys 216	Particles and Fields II (3)
Phys 254	Optics Laboratory (2)
Phys 340	Thermal Physics (3)
Phys 362	Atomic and Molecular Structure (3)
Math 219, 220	Principles of Analysis (6)
Math 205	Linear Methods (3)
	approved electives (8)

The engineering physics curriculum below may serve as a useful guide in designing the sequence for the bachelor of arts physics major.

Engineering Physics in Engineering and Physical Sciences

freshman year (see page 43)

sophomore year, first semester (15 credits)

Phys 21, 22	Introductory Physics II and Laboratory (5)
Math 23	Analytical Geometry and Calculus III (4)
	General Studies requirement (3)
	elective (3)

sophomore year, second semester (17)

Phys 31	Introduction to Quantum Mechanics (3)
Phys 90	Electrical Phenomena (1)
Math 205	Linear Methods (3)
Eco 1	Economics (4)
	electives (6)

junior year, first semester (14-17)

Phys 191	Laboratory Techniques (2)
Phys 212	Electricity and Magnetism I (3)
Phys 215	Particles and Fields I (3)
Math 322	Methods of Applied Analysis I (3)
	electives (3-6)

junior year, second semester (17)

Phys 254	Optics Laboratory (2)
Phys 213	Electricity and Magnetism II (3)
Phys 216	Particles and Fields II (3)
	General Studies requirement (3)
	electives (6)

senior year, first semester (14-17)

Phys 340	Thermal Physics (3)
Phys 362	Atomic and Molecular Structure (3)
	General Studies requirement (3)
	electives (5-8)

senior year, second semester (15)

Phys 171	Proseminar (1)
	General Studies requirement (3)
	electives (11)

The electives include at least fourteen credit hours of approved technical electives, including two of the courses Phys 346, 363, 364, 365, 366, 367, 368 and 369.

The use of electives. The liberal number of electives provided in both physics curricula provides the student with an opportunity to develop special interests and to prepare for graduate work in various allied areas. The student is urged to reflect upon how to take advantage of this opportunity. A student contemplating graduate work in physics should consider the many upper-level physics and mathematics courses available, as well as some of the beginning graduate courses. In addition, note that some graduate schools require a reading knowledge of a modern foreign language.

Students contemplating using electives to develop a special area of interest should try to plan such a program as soon as possible by consultation with members of the faculty. Since many possibilities exist, it is impractical to list all such programs. Instead, two such programs are listed below to serve as guides for those with interests in those areas and to serve as models for those interested in developing their own programs in other areas.

Biophysics

Bio 21	Principles of Biology (3)
Bio 28	Genetics (3)
Bio 135	Microbiology (3)
Bio 320	Cell Physiology (3)
Chem 51	Organic Chemistry (3)
Chem 187	Physical Chemistry (3)
Chem 371	Elements of Biochemistry (3)
Chem 372	Elements of Biochemistry II (3)
Phys 367	Introduction to Molecular Biophysics (3)
Phys 368	Molecular Biophysics (3)

Solid-State Electronics

Met 91	Elements of Materials Engineering (3)
EE 20	Introductory Circuit Theory (4)
EE 103	Physical Electronics (3)
EE 105	Electronics Circuits (3)
EE 308	Transistor Theory (3)
EE 351	Microelectronics (3)
Phys 363	Physics of Solids (3)

Undergraduate Courses in Physics

11. Introductory Physics I (4) fall-spring
Kinematics, frames of reference, laws of motion in Newtonian theory and in special relativity, conservation laws, as applied to the mechanics of mass points; temperature, heat and the laws of thermodynamics; kinetic theory of gases. Two lectures and two recitations per week. Prerequisite: Math 21, 31 or 41, previously or concurrently. Folk

12. Introductory Physics Laboratory I (1) fall-spring
A laboratory course taken concurrently with Phys 11. Experiments in mechanics, heat, and DC electrical circuits. One three-hour laboratory period per week.

13. General Physics (3) spring
A continuation of Phys 11, primarily for students in the College of Arts and Science and premedical students. Electrostatics, electromagnetism, light, fluid mechanics, atomic physics, nuclear physics and radioactivity, introduction to biophysics. Prerequisites: Phys 11 and Math 21, 31 or 41. Benson

14. General Physics Laboratory (1) spring
A laboratory course to be taken concurrently with Phys 13. Prerequisites: Phys 12 and Phys 13, preferably concurrently.

21. Introductory Physics II (4) fall-spring
A continuation of Phys. 11. Electrostatics and magnetostatics; DC circuits; Maxwell's equations; waves; physical and geometrical optics; introduction to modern physics. Two lectures and two recitations per week. Prerequisites: Phys 11 and Math 23, 32, or 44 previously or concurrently. Radin or Sands

22. Introductory Physics Laboratory II (1) fall-spring
A laboratory course to be taken concurrently with Phys 21. One three-hour laboratory period per week. Prerequisites: Phys 12; and Phys 21, preferably concurrently.

31. Introduction to Quantum Mechanics (3) spring
Experimental basis and historical development of quantum mechanics; the Schrodinger equation; one-dimensional problems; angular momentum and the hydrogen atom; many-electron systems; spectra; selected applications. Three lectures per week. Prerequisites: Phys 13 or 21; and Math 205, previously or concurrently.

32. Modern Physics Laboratory (1)
Laboratory experiments dealing with quantum physics, and illustrative of material covered in Phys 31. One three-hour laboratory period per week. Prerequisite: Phys 21.

42. Physics for Poets (3) spring
The course designed for the nontechnical student. Topics are selected from the 17th and 20th-Century revolutions in physics which produced mechanics, relativity and quantum mechanics. These subjects have had profound and far-reaching effects on our society and on our philosophical outlook. High school physics is not assumed. Two recitation periods and one laboratory period per week. No prerequisites. Kanofsky

90. Electronics (1) spring
Laboratory studies of DC and AC circuits, solid-state circuit elements, and transistor amplifiers.

171. Physics Proseminar (1) spring
Discussion of current problems in physics. Intended for seniors majoring in the field.

191. Laboratory Techniques (2) fall
Thermometric, calorimetric and vacuum techniques. Advanced electrical measurements. Prerequisites: Phys 21 and 22, or 13 and 14.

192. Advanced Physics Laboratory (2-3) fall
Laboratory experiments in modern physics designed to introduce students to measuring techniques and phenomena of current interest. Work is of a project nature, and students are placed largely on their own initiative. Intended for seniors majoring in the field.

193. Advanced Physics Laboratory (1-2) spring
Continuation of Phys 192. Intended for seniors majoring in the field.

For Advanced Undergraduates and Graduate Students

212. Electricity and Magnetism I (3) fall
Electrostatics, magnetostatics, and electromagnetic induction. Prerequisites: Phys 21 or 13; and Math 205 previously or concurrently. Radin

213. Electricity and Magnetism II (3) spring
Maxwell's equations; electromagnetic waves with applications to optics. Prerequisite: Phys 212. Wheeler

215. Particles and Fields I (3) fall
Foundations of mechanics of mass points and systems of particles. Conserved quantities. Force laws, mathematical formulation and solution of the motion of mass points and systems of mass points. Prerequisites: Phys. 21 or Phys. 13; Math 205, previously or concurrently. Fowler

216. Particles and Fields II (3) spring
Continuation of Phys. 215. Rigid body motion. Elasticity and fluid mechanics, employing tensor notation. Sound waves. Dimensional analysis and similitude. Lagrange generalized coordinates and solutions of problems by Lagrange equations. Prerequisite: Phys. 215. Emrich

254. Optics Laboratory (2) spring
Optical instruments and techniques. Examination of phenomena, of measuring procedures, and of light sources and recording devices. Prerequisite: Phys 21 or 13.

281. Basic Physics I (3) summer
A course designed especially for secondary-school teachers in the master teacher program. Presupposing a background of two semesters of college mathematics through differential and integral calculus and of two semesters of college physics, the principles of physics are presented with emphasis on their fundamental nature rather than on their applications. Open only to secondary-school teachers and those planning to undertake teaching of secondary-school physics.

282. Basic Physics II (3) summer
Continuation of Phys 281.

300. Apprentice Teaching in Physics (1-3)

340. Thermal Physics (3) fall
Basic principles of thermodynamics, kinetic theory, and statistical mechanics, with emphasis on physical systems. Prerequisites: Phys 13 or 21, and Math 23, 32 or 44. Smith

346. Physics of Developing Energy Sources (3) spring
Basic concepts, theoretical development, and experimental techniques pertaining to developing energy sources. Topics include thermonuclear, magnetohydrodynamic, solar and other potential sources of energy. Prerequisite: senior standing in the College of Engineering and Physical Sciences, or consent of chairman of the department. Kim

352. Modern Optics (3)
Paraxial optics, wave and vectorial theory of light, coherence and interference, diffraction, crystal optics, and lasers. Prerequisites: Math 23, and Phys 21 or 13. Bergmann

362. Atomic and Molecular Structure (3) fall
Structure of atoms and molecules, especially as related to their spectra. Prerequisite: Phys 31 or Chem 191. Kim

363. Physics of Solids (3) spring
Introduction to the theory of solids with particular reference to the physics of metals and semiconductors. Prerequisite: Phys 31 or Met 316 or Chem 191. Watkins

364. Nuclear Physics (3) spring
Nuclear models and properties of nuclei. Interaction of nuclear radiation with matter and applications. Radioactive decay; phenomenology and theory. Radiation and particle detectors. Nuclear reactions. High-energy physics. Accelerators. Practical nuclear physics applications. Prerequisites: Phys 31 and Math 205. Shaffer

365. Physics of Fluids (3) fall
Concepts of fluid dynamics; continuum and molecular approaches; waves, shocks and nozzle flows; nature of turbulence; experimental methods of study. Prerequisites: Phys 212 or EE 231, and Phys 340 or ME 104 or equivalent, previously or concurrently. Emrich

366. Ocean Physics (3)
Underwater sound and optics, thermodynamics of the oceans, other topics in physical oceanography such as currents, tides and waves. Prerequisites: Math 205 and Phys 21 or 13. Van Sciver

367. Introduction to Molecular Biophysics (3) fall
A development of the molecular basis of life in terms of physical principles. Topics include molecular biology of the gene, energy flow as an organizing factor in biology, intra- and inter-molecular interactions, and the determination of macro-molecular structure and function. Techniques discussed include ultracentrifugation, optical spectroscopy, and X-ray diffraction. Prerequisite: Phys 13 or 21. Benson, Sands

368. Molecular Biophysics (3) spring
Further topics in molecular biophysics including the problems of membrane structure and function, the action of radiation on cells and the structure of cell water. Techniques discussed include electron spin resonance, nuclear magnetic resonance, molecular probes and calorimetry. Prerequisites: Phys 367 or consent of the department chairman. Sands, Benson

369. Introduction to Quantum Mechanics (3) fall
Principles of quantum mechanics: Schrodinger, Heisenberg, and Dirac formulations. Applications to simple problems. Prerequisites: Phys. 31, 216, Math 205. Watkins

372. Special Topics in Physics (1-3)
Special topics in physics not sufficiently covered in the general courses. Lecture and recitations or conferences.

For Graduate Students

The department of physics has concentrated its research activities within several fields of physics, with the result that a number of projects are available in each area. Current departmental research activities include the following:

Solid-state physics (experimental). Optical properties of insulators, defects in insulators, electron paramagnetic resonance, properties of thin films.

Solid-state physics (theoretical). Energy band calculations in insulators, excited states and lifetimes of defects, properties of impurities in insulators.

Molecular biophysics. Magnetic resonance studies of nucleic acid derivatives. Molecular virology. Membrane biophysics.

Ocean physics. Optical absorption and luminescence of organic and inorganic materials in sea and ice.

Plasma spectroscopy. Collisional and collisionless phenomena of very dense plasmas.

Nuclear theory. The few nucleon problem, nuclear structure theory.

Physics of fluids. Transition from laminar to turbulent flow in boundary layers, microscopic fluctuations in a flow, shock-induced reactions in gases, energy transfers, relaxation times, lifetimes, and phase transitions at liquie-vapor interfaces.

Statistical physics. Kinetic theory, transport in plasmas with strong magnetic fields, statistical basis of hydrodynamics, nonlinear processes.

Elementary particles (experimental). Experiments are performed both at Lehigh and at the various national accelerator facilities at Fermilab, Argonne ZGS, and Brookhaven AGS. These include cosmic ray studies; production of jets (Fermilab); high-energy particle channeling (Fermilab); Kaon-induced hypernuclei (AGS); particle-nuclei reactions (ZGS).

Elementary particles (theoretical). Properties of leptons, the vector boson, methods for handling unrenormalized field theories, electromagnetic interactions.

Laser physics. Construction of gas lasers and studies of their characteristics; use of gas lasers in determination of oscillator strength and atomic parameters; mode structure; holography.

Candidates for advanced degrees normally will have completed, before beginning their graduate studies, the requirements for a bachelor degree with a major in physics, including advanced mathematics beyond differential and integral calculus. Students lacking the equivalent of this preparation will make up deficiencies in addition to taking the specified work for the degree sought.

Doctoral candidates may be required by their thesis committee to demonstrate a reading knowledge of one language, usually chosen from French, German or Russian. Some graduate work in mathematics is usually required; and certain advanced courses in other fields, notably mechanics, metallurgy and materials engineering, electrical engineering, and chemistry, may be included in a graduate program. Further details regarding the special requirements for degrees in physics may be obtained on application to the department chairman.

At least eight semester hours of general college physics using calculus are required for admission to all 200- and 300-level courses. Additional prerequisites for individual courses are noted

in the course descriptions. Admission to 400-level courses generally is predicated on satisfactory completion of corresponding courses in the 200- and 300-level groups or their equivalent.

Special departmental facilities for teaching and research include cosmic ray detection apparatus consisting of scintillation counters and a streamer chamber; three shock tubes, two minicomputers, six lasers, and other advanced instrumentation for the study of the physics of fluids; an ultracentrifuge, a cobalt-60 source and magnetic resonance equipment used in biophysics. The adjacent Sherman Fairchild Laboratory for Solid-State Studies, opened in 1976, is the center for solid-state activity on campus. It houses a 3 MeV van de Graaff accelerator and related instrumentation; two minicomputers; optical, electronic, cryogenic, and magnetic resonance equipment; crystal and device fabrication facilities and other research facilities and equipment. Other related equipment is available at the Materials Research Center and at the Center for Surface and Coatings Research.

Faculty from the physics department participate in the interdisciplinary master of science and doctor of philosophy programs in molecular biology. These are described in Section IV.

Graduate Courses in Physics

420. Theoretical Physics (3) fall
This and the three courses, Phys 421, 422 and 423, cover the classical theory of particles and fields. Phys 420 includes the variational methods of classical mechanics, methods of Hamilton and Lagrange, canonical transformations, Hamilton-Jacobi theory. Smith

421. Theoretical Physics (3) spring
Theory of elasticity; fluid dynamics; tensor analysis; electrostatics and magnetostatics. Prerequisite: Phys 420. Van Sciver

422. Advanced Theoretical Physics (3) fall
Electromagnetic radiation; dyanmics of charged particles; multipole fields; special theory of relativity and covariant formulation of electrodynamics. Prerequisite: Phys 421. Van Sciver

423. Advanced Theoretical Physics (3) spring alternate years
Electrodynamics in anisotropic media; physical optics; theory of diffraction and application to holography; applications of electrodynamics in various fields of physics. Prerequisite: Phys 422. Bergmann

424. Quantum Mechanics (3) spring
General principles of quantum theory; approximation methods; spectra; symmetry laws; theory of scattering. Prerequisite: Phys 369 or equivalent. Fowler

425. Quantum Mechanics (3) fall, even-numbered years
A continutation of Phys 424. Relativistic quantum theory of the electron; theory of radiation. Shaffer

428. Methods of Mathematical Physics (3) fall
The equations of theoretical physics and the methods of their solution. Folk

429. Methods of Mathematical Physics (3) spring
Continuation of Phys 428. Folk

431. Theory of Solids (3) fall, odd-numbered years
Advanced topics in the theory of the electronic structure of solids. Many-electron theory. Theory of transport phenomena. Magnetic properties, optical properties. Superconductivity. Point imperfections. Desirable preparation: Phys 363 and Phys 424. Fowler

434. Solids and Radiation (3)
Phenomena in solids resulting from interaction with electromagnetic radiation or charged particles. Current theories of energy absorption, transport and emission. Prerequisite: Phys 363 or equivalent.

442. Statistical Mechanics (3) fall
General principles of statistical mechanics with application to thermodynamics and the equilibrium properties of matter. Prerequisites: Phys 340 and 369. McLennan

443. Statistical Mechanics (3) spring, odd-numbered years
A continuation of Phys 442. Applications of kinetic theory and statistical mechanics to nonequilibrium processes; nonequilibrium thermodynamics. Prerequisite: Phys 442. McLennan

447. (Biol 447, Chem 447) Experimental Molecular Biology (3)
A survey of current research in molecular biology.

451. Topics in Biophysics (1-3) alternate years
An intensive study of recent advances in a selected area of biophysics. May be repeated for credit when a different topic is offered. Prerequisite: Phys 368. Benson, Sands

462. Theories of Elementary Particle Interations (3)
Relativistic quantum theory with applications to the strong, electromagnetic and weak interactions of elementary particles. Prerequisite: Phys 425. Shaffer

465. Nuclear and Elementary Particle Physics (3) spring, 1980
Nuclear structure and phenomena; interactions among elementary particles and methods of studying them. Kanofsky

467. Nuclear Theory (3) spring, odd-numbered years
Theory of low-energy nuclear phenomena within the framework of nonrelativistic quantum mechanics. Borse

471. (Mech 411) Continuum Mechanics (1-3)
An introduction to the nonlinear continuum theories of the mechanics of solids and fluids. This includes discussion of the mechanical and thermodynamic bases of the subject, as well as the use of invariance principles in formulating constitutive equations. Applications of the nonlinear theories to specific problems are given. Rivlin

472. Special Topics in Physics (1-3)
Selected topics not sufficiently covered in the more general courses. May be repeated for credit.

474. Seminar in Modern Physics (3)
Discussion of important advances in experimental physics.

475. Seminar in Modern Physics (3)
Discussion of important advances in theoretical physics.

491. Research (3)
Research problems in experimental or theoretical physics.

492. Research (3)
Continuation of Phys 491. May be repeated for credit.

Psychology

Professors. Arthur L. Brody, Ph.D.; Josef M. Brozek, Ph.D.
Associate professors. Edwin J. Kay, Ph.D.; William Newman, Ph.D., *chairman* (effective July 1, 1979); Martin L. Richter, Ph.D., *chairman* (through June 30, 1979); George K. Shortess, Ph.D.
Assistant professors. William H. Atkinson, Ph.D.; Joyce D. Clark, Ph.D.; Ellen C. Herrenkohl, Ph.D.; John G. Nyby, Ph.D.
Adjunct professors. David W. Durka, Ph.D.; Lawrence M. Paul, Ph.D.; John B. Siegfried, Ph.D.; Mervin P. Smolinsky, Ph.D.

The bachelor of arts in psychology is a natural science major requiring a minimum of twenty-four credit hours in psychology as defined below. This is a revised program effective for students entering with the class of 1982. Second-semester freshmen who have completed Psych 1 can enroll in the 100-level courses by petition, and should check with the chairman of the psychology department if interested.

Required Major Courses

Psych 1	Introduction to Psychology (3) P NS SS fall-spring
Psych 113	Psychological Research and Statistics (3) NS fall
Psych 114	Psychological Research and Statistics (3) NS spring

Plus the following

at least one from	
Psych 107	Child Psychology (3) SS fall
Psych 154	Clinical Approaches to Human Behavior (3) SS spring
at least one from	
Psych 171	Learning Processes and Applications (3) NS fall
Psych 176	Introduction to Psychophysiology (3) NS spring
at least one from	
Psych 305	Abnormal Psychology (3) SS fall
Psych 331	Humanistic Psychology (3) SS spring
Psych 353	Personality Teory (3) SS fall
at least one from	
Psych 307	Cognitive Psychology (3) NS fall
Psych 311	History of Psychology (3) NS fall
Psych 371	Learning (3) NS spring
at least one from	
Psych 373	Sensory Psychology (3) NS spring
Psych 375	Physiological Psychology (3) NS fall
Psych 382	Comparative Psychology (3) NS spring

Additional Required Courses

These fulfill College of Arts and Science distribution requirements. They are Elective courses which bring the credit-hour total to 120.

The bachelor of arts program in psychology is a flexible preparation for a number of fields. With a suitable selection of additional courses, students can prepare themselves for graduate study in clinical psychology, developmental psychology, social psychology, or personality, or for careers in areas for which psychology is a desirable and relevant major, e.g., law, social work, nursing, or special education. Courses recommended, in addition to those major courses listed above, are:

Psych 162	Psychological Field Work (1-3)	
SR 21	Social Psychology (3)	
Math 41	BMSS Calculus (3)	
Biol 21	Principles of Biology (3)	*or*
Biol 28	Genetics (3)	

With greater emphasis on mathematics and science, the program provides preparation for graduate study in experimental psychology, medicine or dentistry. In this case, additional recommended courses are:

Psych 162	Psychological Field Work (1-3)	
Psych 372	Learning Laboratory (1)	
Psych 374	Sensory Processes Laboratory (1)	
Psych 376	Physiological Psychology Laboratory (1)	
Math 21, 22, 23	Analytic Geometry and Calculus (12)	*or*
Math 31, 32	Calculus (8)	*or*
Math 41, 42, 43, 44	BMSS Calculus, Probability, Linear Algebra, Calculus (12)	
Biol 21, 22	Principles of Biology and Laboratory (4)	
Chem 21, 22	Introductory Chemical Principles and Laboratory (5)	
Phys. 11, 12	Introductory Physics I and Laboratory (5)	
Phil 42 or 261 or 301	philosophy of science course (3)	

plus additional electives in mathematics, probability, statistics, computing and information science, biology, chemistry and physics.

The Psychology Minor

The psychology minor consists of fifteen credits hours in psychology chosen by the student together with a faculty adviser from the psychology department.

Undergraduate Courses

Note: As with other course listings, the code initials on the first line of each entry indicate the course's distribution-level rating. The next entry, NS or SS, applies only to psychology courses and refers to Natural Science or Social Science distribution requirements. Some listings also state the semester in which the course is customarily offered.

1. Introduction to Psychology (3) P NS SS fall-spring
Psychology as a science of behavior. Natural science aspects such as learning, sensation-perception, and physiological bases; and social science aspects such as human development, intelligence, and personality. Methodologies appropriate to these areas, and related societal problems.

21. (SR 21) Social Psychology (3) P SS
Theories, methods of investigation, and results of research in social psychology with emphasis on psychological processes in social behavior, social attitudes, group behavior, and social interaction. Not offered to students who have had SR 7.

65. Perception and the Visual Arts (3) PNS
Perceptual and cognitive theories and principles as related to visual fine arts and aesthetic experience. Shortess

75. (Phil 75) Behavior Control and Human Values (3) P SS fall
Philosophical examination of operant conditioning techniques for controlling behavior. Value problems related to automony of individual choice, responsibility, rationality, freedom and dignity, and punishment. To what end shall behavior be controlled, and who will control the controllers? Prerequisite: an introductory course in either psychology or philosophy, or consent of department chairman. Brody, Melchert

81. Insanity: Psychological and Legal Views (3) PSS
Problems with the concept of insanity, its use and misuse; commitment procedures, incompetency, and the insanity defense; the right to treatment and to refuse treatment; the right to be different and the dangers of a therapeutic community. Prerequisite: Psych 1. Brody

107. Child Psychology (3) SS fall
Theories and data concerning the development of the human organism from fetus to adolescent. Emphasis is placed on the methods and techniques employed. Prerequisite: Psych 1.

108. Adolescent and Adult Psychology (3) SS
Descriptions and explanations of the development process from adolescence to death. Stresses of adolescence, changes during adulthood, and ways with dealing with old age and death. Prerequisite: Psych 1.

113. Psychological Research and Statistics (3) NS fall
Basic data, research methods, and statistics in a variety of subject areas. Design of experiments with human and other animals; data collection, analyses, reports. Prerequisite: Psych 1. Kay, Richter

114. Psychological Research and Statistics (3) NS spring
Continuation of 113; independent research project. Prerequisite: Psych 113. Kay, Richter

121. Encountering Self and Others (3) SS fall-spring
An experientially oriented course to facilitate personal growth and develop a fuller awareness of personal functioning and interpersonal perception and communication. Pass-fail grading. Prerequisites: consent of the department chairman. Newman

131. Psychology of Women (3) SS fall
Biological, cross-cultural, sociological and psychological perspectives on women, with reference to personal experience where appropriate. Prerequisite: Psych 1 or an introductory social relations course, and consent of the department chairman.

154. Clinical Approaches to Human Behavior (3) SS spring
Therapeutic approaches and their theoretical foundations: Psychoanalysis, client-centered, Gesalt, rational-emotive, behavioral, and existential therapies. This is not a how-to-do-it course in psychotherapy. Prerequisite: Psych 1.

160. Independent Study (1-3) NS SS fall-spring
Readings on topics selected in consultation with a staff member. Prerequisites: Psych 1 and consent of the department chairman. May be repeated for credit. Fulfills natural science or social science distribution requirements for students in the College of Arts and Science by petition only.

161. Independent Research (1-3) NS SS fall-spring
Research in areas selected in consultation with a staff member.

Prerequisites: Psych 1 and 111 or 114 and consent of the department chairman. May be repeated for credit. Fulfills natural science or social science distribution requirements for students in the College of Arts and Science by petition only.

162. Psychological Field Work (1-3) SS fall-spring
Work-study practice including supervised experience in one of several local agencies. Development of familiarity with the operations of the agency and working with individual patients or students. Prerequisites: Psych 1 and consent of the department chairman. May be repeated for credit.

171. Learning Processes and Applications (3) NS fall
Experimental data on animal and human conditioning and learning. Applications to mental health, mental retardation, education. Prerequisite: Psych 1. Brody, Richter

176. Introduction to Psychophysiology (3) NS spring
Physiological correlates of behaviorally defined psychological conditions in humans: sleep, stress, emotion, and anxiety; psychosomatic disorders, lie detection, and psychopathology. Prerequisite: Psych 1. Nyby, Shortess

201. Industrial Psychology (3) SS spring
Psychological concepts and methods applied to business and industrial settings. Personnel selection, placement and training, leadership, work motivation, and job satisfaction; and consumer behavior. Prerequisite: Psych 1.

241. Psychological Principles in Systems Design (3) SS
Application of experimental psychology to facilitate the interaction between people and machines, and between tasks and environments. Human capacities, limitations, and requirements; traditional engineering psychology considerations; man as part of a social and environmental system. Prerequisite: Psych 1.

243. Construction of Psychological Reality (3) SS
The relationship between cognitive structures and world view, particularly the influence of language on perception, and the cultural context of learning and thought. Contributions of B.L. Whorf, Michael Polanyi, John Lilly, Michael Cole, and others. Prerequisite: at least six credit hours in psychology. Newman

300. Apprentice Teaching in Psychology (1-3) NS SS fall-spring
Fulfills Natural Science or Social Science distribution requirements for students in the College of Arts and Science by petition only.

303. Mathematical Models in Psychology (3) NS
The application of mathematics in psychology, including models for psychophysics, learning acquisition curves, discrimination learning, concept formation and probability learning. Prerequisite: Psych 111, 114, or consent of the department chairman.

305. Abnormal Psychology (3) SS fall
The patterns, causes, and treatment of various forms of abnormal behavior. Supplemented by sessions at Allentown State Hospital. Prerequisites: Psych 1, and three additional hours of psychology or consent of the department chairman.

307. Cognitive Psychology (3) NS fall
Processing of information by human beings. Topics include contemporary theories of perception, attention, memory, and decision-making. Prerequisite: Psych 1.

308. (IS 320) Information Processing: Human & Machine (3) NS
Study of the identification, storage, retrieval, and use of auditory and visual inputs in decision-making contexts. Human and mechanical information processes, their similarities and differences. Rubenstein

309. Statistical Analysis (3) NS fall
Theory and practice of analysis of data in psychology. Descriptive statistics. Hypothesis testing. Tests of inference: chi-square, t-test, correlation, analyses of variance. Kay

311. History of Modern Psychology (3) NS fall
History of psychology, with emphasis on the emergence and growth of scientific study of behavior. Includes the rating of primary sources and the autobiographies of the major contributors to the field. Prerequisite: Psych 1. Brozek

320. (HD 320) Psycholinguistics (3) SS spring
Study of the experimental and observational literature on psychological processes involved in the production, comprehension, and use of language by adults. Rubenstein

324. (HD 324) Life-Span Cognitive Development (3) SS
Changes in perception, learning, memory, and problem solving from infancy to old age. Rubenstein

331. Humanistic Psychology (3) SS spring
The literature of and metaphors underlying the humanistic point of view in psychology. These "models of man" are contrasted with models underlying other modes of psychological inquiry. Prerequisite: Psych 1. Newman

353. Personality Theory (3) SS fall
Review and critique of theories of personality and their associated systems of psychotherapy. Includes developing knowledge and theory about people as well as the theoretical concepts themselves. Prerequisite: Psych 1.

354. Personality Assessment (3) SS spring
Methods of describing and measuring personality. Observational techniques, interviews, self-report inventories, intelligence tests, and projective tests. Prerequisites: Psych 1, and consent of the department chairman.

371. Learning (3) NS spring
Principles of learning with emphasis on reinforcement, discrimination, motivation, verbal learning and memory. Critical evaluation of classical and contemporary theories of learning. Prerequisite: Psych 1. Brody, Richter

372. Learning Laboratory (1) NS spring
Experimentation on the learning process utilizing animal and human subjects. Prerequisites: Psych 111 or 114; Psych 371, previously of concurrently. Brody, Richter

373. Sensory Processes (3) NS spring
Receptor processes of vision, audition, touch, taste and smell are considered with particular emphasis on problems of sensory intensity, sensory discrimination functions and perceptual processes. Quantitative methods are stressed. Prerequisites: Psych 1. Shortess

374. Sensory Processes Laboratory (1) NS spring
Laboratory exercise applying quantitative methods to the study of sensory processes. Prerequisites: Psych 111 or 114; Psych 373, previously of concurrently. Shortess

375. Physiological Psychology (3) NS fall
The physiological basis of behavior, both human and animal. Particular emphasis is placed on the neural mechanisms involved. Prerequisites: Psych 1; eight semester hours of physics, chemistry or biology. Nyby, Shortess

376. Physiological Psychology Laboratory (1) NS fall
A survey of techniques in physiological psychology. Prerequisite: Psych 375 previously or concurrently. Nyby, Shortess

382. Comparative Psychology (3) NS spring
Animal and human behavior from an evolutionary, genetic, and physiological perspective: sex behavior, aggression, territoriality, animal communication, and learning. Prerequisite: Psych 1. Nyby

383. Personality (3)
Review and analysis of psychological concepts and data relevant to the development and functioning of personality. Comparison and critical examination of the major historical schools of personality theory. Prerequisite: Psych 1 or consent of the department chairman. Open only to graduate students in the School of Education. Smolinsky

For Graduate Students

The current emphasis in the graduate program is on the development of the doctor of arts (DA) degree, which is a doctoral degree for teaching.

Most employment opportunities for people with doctoral degrees in psychology involve at least some teaching, and yet, the traditional doctor of philosophy model places its primary emphasis on the development of research skills. There seems to be an implicit assumption that teaching skills are either not important or not learnable.

Lehigh does not accept either of these assumptions and therefore offers a doctoral program emphasizing the teaching of psychology, while continuing to include training in research and experimental skills. The doctor of arts program presents psychology as an experimental science and stresses the ability to design and critically analyze research. However, the goal is to prepare people for careers in college teaching at two- and four-year colleges rather than in institutions emphasizing research.

The doctor of arts program differs in a number of ways from the traditional doctor of philosophy program. It encourages greater breadth of coverage within the various areas of psychology including courses dealing with issues and techniques for college teachers, requires extensive teaching experience including a supervised internship, has training in interpersonal awareness, and substitutes a doctoral project involving problems of teaching and learning for the traditional research dissertation. In addition, the program requires an empirical master's thesis, a comprehensive general examination, and a minor concentration of courses from outside the psychology department. Training in the doctor of arts program also stresses the acquisition of skills applicable to teaching and research such as course preparation, report writing, and audio-visual aids (videotape, programming and electromechanical research techniques).

The beginning student is required to take during the first year: Analysis and Design of Experiments, a one-year course in theoretical and applied statistics and research methodology; Doctor of Arts Seminar, discussions including first and second year students on various topics of concern to teachers; Projects in Research, an apprentice-style research and communication experience; two content courses; and one of the following two courses: College Teaching of Psychology or Interpersonal Awareness.

In subsequent years the student is required to complete a core of content courses within psychology and additional courses and experiences in teaching, as well as the examination and project requirements described above. A general examination is administered to all candidates for a doctoral degree (recommended no later than the end of the third year), and there is an oral final examination focusing on the doctor of arts project. At the end of every semester, each graduate student is evaluated by the faculty concerning the progress in the graduate program. The evaluation is based on performance in examinations in Analysis and Design of Experiments and content courses, progress in research, and performances in teaching-oriented courses and teaching experiences.

Lehigh's psychology department is small enough to provide a personalized approach to graduate study. The student-faculty ratio is approximately one-to-one. Since the doctor of arts program is in a continuing state of development, it is hoped that graduate students will play an active role with the faculty in shaping and improving the doctor of arts program during their stay at Lehigh.

How to apply. Applications for admission and financial aid may be obtained from the department of psychology. Completed application forms plus transcripts, letters of recommendation, and a report of scores on the Graduate Record Examination aptitude tests and advanced test in psychology should be returned to the office of admission not later than February 1 of the year of admission.

Normally, new students are accepted for entrance into the program only for the fall semester. Financial support is available in the form of teaching and research assistantships, fellowships and scholarships. There are special fellowships for minority students. While a good undergraduate background in psychology is desirable, promising students with majors other than psychology are encouraged to apply.

Research Interests

The current permanent faculty members describe their research and scholarly interests as follows: Arthur Brody, learning and learning theory, psychological and legal views of insanity, behavior modification; Josef Brozek, history of psychology, Soviet and East European psychology, impact of malnutrition on behavior; Edwin J. Kay, mathematical models, learning and memory, psychopharmacology; William Newman, group process in humanistic psychology, state of consciousness and perceived quality of life, higher education, student drug use; Martin Richter, discrimination learning and cognition, statistics and quantitative psychology; George K. Shortess, physiological processes underlying sensory processes, vision and sensory interaction in relation to aesthetic experience. Three new faculty members will add their own special interests to the areas listed above.

Graduate- Level Courses

409. Doctor of Arts Seminar (1) fall-spring
One-hour meeting per week of first- and second-year graduate students to discuss topics of concern to teachers. May be repeated for credit.

411. Interpersonal Awareness (3)
Designed to improve awareness of personal functioning and to enhance interpersonal perception and communication. Application to problems of teaching and learning. Prerequisite: consent of the department chairman. May be repeated for credit. Newman

421. Analysis and Design of Experiments (3) fall
First of a two-semester sequence covering a variety of issues in theoretical and applied statistics with emphasis on inferential statistics and analysis of variance. Kay

422. Analysis and Design of Experiments (3) spring
Continuation of Psych 421. Prerequisite: Psych 421. Kay

434. Special Topics in Personality (3)
Selected topics in personality theory and research, including but not limited to personal change, ego psychology, and psychology of women. May be repeated for credit.

438. Special Topics in the History of Psychology (3)
Contemporary historiography of psychology; methods of historiography, with special reference to quantitive and archival research; roots of experimental psychology in experimental psychology; history of Russian and Soviet psychology; history of research on visual functions. May be repeated for credit. Brozek

441. Communicating Psychological Concepts (3)
How to organize facts and ideas into broader meaningful units that are readily communicable. Includes media aids and the structured experience as a communication aid. Prerequisite: consent of the department chairman. Newman

448. (CIS 402) Seminar in Psycholinguistics (3)
Selected topics in psycholinguistics examined in depth and in detail. Prerequisite: CIS 302. Rubenstein

450. Special Topics in Mathematical Models and Statistics (3)
Selected topics in the application of mathematics to psychological theory and the application of statistics to psychological research. May be repeated for credit. Brody, Kay, Richter

453. Advanced Topics in Learning (3)
An intensive study with emphasis on current research of discrimination learning, avoidance learning, concept learning, problem solving, or verbal learning. May be repeated for credit. Brody, Richter

460. Special Study (1-3) fall-spring
Study of some special topic not covered in the regular course offerings. May be repeated for credit.

461. Research (1-3) fall-spring
Original research not connected with master's or doctoral thesis. May be repeated for credit.

463. College Teaching of Psychology (3) fall-spring
Consideration of problems in the preparation and presentation of college courses in psychology; ancillary problems associated with the profession of psychology; practice in teaching. May be repeated for credit.

464. Projects in Research (3) spring
One or more research projects carried out in apprenticeship with a faculty member; course concludes with written and oral reports based on these projects.

465. Teaching Internship (3-6) fall-spring
The preparation, teaching and grading of one or two undergraduate courses with appropriate supervision by members of the faculty. Observation and evaluation of the intern via classroom visits and videotapes. May be repeated for credit.

471. Applied Psychology Internship (1-6) fall-spring
Supervised, independent field work experience in e.g., industry, a medical setting, or a mental health setting. May be repeated for up to six hours credit.

472. Special Topics in Physiological Psychology (3)
Selected topics from sensory psychophysiology, drive, short-term memory mechanisms, bioelectrics, etc. May be repeated for credit. Shortess

474. Special Topics in Developmental Psychology (3)
Topics selected from such areas as socialization and the parent-child interaction, personality disorders in childhood, moral development and cognitive development. May be repeated for credit.

476. Special Topics in Cognition (3)
Selected topics in human information processing including perception, attention, memory, thinking, and decision making.

Religion Studies

Professor. A. Roy Eckardt, Ph.D., *chairman.*
Associate professors. Hubert L. Flesher, M.A.; Park McGinty, Ph.D.
Assistant professor. Alice L. Eckardt, M.A.

As an intrinsic dimension of culture, religion exerts abiding influence upon human thought, affect, and behavior. This fact furnishes the rationale for the study of religion at Lehigh. The department of religion studies is committed to forms of intellectuality identical with those pursued in other humanistic and scientific disciplines. The primary purpose in the department is to foster and complete the individual student's liberal education. Secondarily, the scholarly analysis of religion comprises one foundation for a mature personal and social faith.

Courses afford a comprehensive understanding of the world's major religious traditions and their contributions to human culture. The curriculum extends through the methodology of and introduction to religion study, the history of religions in East and West, biblical studies, the place of personal and social religion within a secular culture, influential theological movements and issues, and the relating of religion and theology to contemporary moral, social, and aesthetic questions.

The study of religion is inherently interdisciplinary. Students who concentrate in religion studies are enabled to emphasize one or more of the above subfields. The major is preparatory to a number of professions and vocations, including the law, medicine, government service, teaching, journalism and business.

Major in Religion Studies

Normally, RS 11, 17 or 18 is the foundational course. A minimum of ten additional courses in the department are selected in consultation with the chairman. Offerings taken should extend to the several subfields of religion study. Some students may desire to pursue a double major of religion studies with another of the humanities, or with one of the the social or natural sciences.

In light of the interdisciplinary character of study in religion, students are encouraged to consult with the department chairman respecting selected collateral work in other fields of the humanities and in the social sciences. Those who plan to pursue graduate work are advised to study a foreign language or foreign languages appropriate to their area of concentration.

Minor in religion studies. Normally, a minor consists of RS 11 or 17 or 18 plus a minimum of four other courses, chosen in consultation with the department chairman.

Recommended freshman distribution courses. Any religion studies course below the 100 level may be taken. With the consent of their advisers, freshman may enroll in RS courses at the 100 level.

Recommended upperclass distribution courses. RS 53, 58, 61, 62 and any course at the 100 level or above may be taken.

Note on Biblical languages. With sufficient student demand, the department will offer for credit instruction in Biblical Hebrew and in the Greek New Testament.

Courses of Study

11. Religions of Man (3) P fall-spring
The world's major religious traditions: Judaism, Christianity, Islam, Hinduism, Buddhism, and Chinese and Japanese religions. McGinty

17. Issues of Faith (3)P fall
The problem of achieving a viable personal faith. Is God real? Is there hope? Does faith conflict with reason and science? How may we decide between conflicting faith-claims? What is man? What is his destiny? Why do people suffer? A.R. Eckardt

18. Religion and Modern Society (3) P spring
The relating of religious principles and theological understanding to a comprehension and resolution of pressing moral and social issues of today: sex, marriage and intermarriage; revolution, the law and civil rights; racism and religious prejudice; biomedical ethics; and problems in ecology. A.R. Eckardt

53. (Hist 53) Religion and the American Experience (3) UP fall
The historical development of major American religious groups from colonial times to the present. Their place in social and political life, and the impact of the national experience upon them. Emphasis on religious freedom and pluralism, and the church-state relationship. A.L. Eckardt

58. Women and Religion (3) UP spring
The images and roles of women within varied religious traditions, especially in the West, and their impact on attitudes and social structures. Such specific issues as goddesses and witches, woman as holy virgin and temptress, religious aspects of the feminist movements and religion as repressive and liberating. Contemporary movements for change. A.L. Eckardt

61. Judaism (3) UP fall
The rise, development, and teachings of the Jewish religion. Emphasis upon practices and beliefs, especially as these affect society and culture. A.L. Eckardt

62. Christianity (3) UP spring
The rise, development, and teachings of the Christian religion. Emphasis upon beliefs and practices, especially as these affect society and culture. Flesher

66. (IR 66) Religion and Politics (3) P spring
Religious and theological assessments of the political order: the role of power in national and international affairs; democracy and leftist and rightist movements; authority in politics and religion; religion, justice, and injustice; the secular state and the church; war, pacifism, and alternate methods of conflict resolution. A.R. Eckardt

111. The Hebrew Bible (3)UP fall
Theological examination of a major portion of the Hebrew scriptures, with emphasis upon literary, historical and critical problems. The Near Eastern context of Hebraic religious development; the Exodus tradition and the Patriarchal Period; the conquest of the land; the development and dissolution of the monarchy; the prophetic movement. Flesher

114. New Testament (3) UP spring
Study of early Christianity, with emphasis upon early Apostolic writings. The Synoptic Gospels; the Fourth Gospel; Paul's writing; the later Epistles; the Apostolic Fathers; the development of Gnosticism; parallel Hellenistic religions; newly discovered secret gospels from the 2nd century. Flesher

121. Religions of India and China (3) fall
The rise, development, and teachings of Hinduism and the Chinese religious tradition. Emphasis on beliefs and forms of practice, especially meditational techniques. McGinty

124. (Phil 124) Reason and Religious Experience (3) spring
A critical look, from a philosophical perspective, at some fundamental problems of religion: the nature of religious experience and belief, reason and revelation, the existence and nature of God, the problem of evil, and religious truth. Hare

126. Buddhism (3)spring
Rise and development of the Buddhist religion, its view of reality, and its meditational practices. The biography of the Buddha; Theravada, early Mahayana, Tibetan, and Zen schools; interactions with society and culture, especially art and politics. McGinty

131. Religion and the Human Sciences (3) fall
Exploration of religion as an aspect of culture. Psychological, anthropological, sociological, political, and phenomenological interpretations of religion, with attention to models of man and reality within these different disciplines. McGinty

133. Science, Theology and Technology (3) fall-spring
The understanding and assessment of our technological and scientific culture through study of such contemporary thinkers as Ian Barbour, Harvey Cox, Jacques Ellul, Pierre Teilhard de Chardin, and Paul Tillich. Flesher

143. (Phil 143) Kierkegaard (1) spring
An introduction to the life and thought of Kierkegaard, the 19th-Century Danish forerunner of existentialism, with a brief look at his impact on philosophy, theology, psychology and literature. Melchert

151. The Jewish-Christian Encounter (3) fall
Analysis of relations between the Jewish community and the Christian church in history and the present. Stress upon moral issues such as antisemitism and upon doctrinal similarities and differences between Judaism and Christianity. Religious and sociopolitical aspects of the reestablishment of the state of Israel. A.R. Eckardt

154. (Hist 154) The Holocaust: History and Meaning (3) spring
The Nazi holocaust in its historical, political and religious setting. Emphasis upon the moral, cultural and theological issues raised by the Holocaust. A.L. Eckardt

157. (Hist 157) The Renaissance and Reformation (3) fall
The transition from medieval to modern society. Consideration of political, economic, and social forces produced by the Renaissance and their influence upon the dominant religious theme of the Reformation era. Baylor

163. Contemporary Theology (3) fall
Major 20th-Century movements within Christian and Jewish theology understood as responses to the problems of modern times. A.R. Eckardt

171. Religion and the Arts (3) fall
Examination of religious themes in such areas as literature, film, and painting, with shifting content from term to term. Alternate fields of study include world literature, modern prose works, the contemporary American novel, and science fiction and fantasy. Flesher

241. (Clss 241) Pagan, Jew and Christian (3) UP fall
Religious groups in the Roman Empire as social phenomena. Reactions to historic circumstances. Similarity and divergence of religious experience. Readings in primary sources. Lectures and discussion. Phillips

242. Methods and Issues (3) spring
Anthropological, sociological, psychological and phenomenological interpretations—especially their models of man and reality—applied to understanding religious phenomena. McGinty

271. Special Topics (1-3) fall-spring
Intensive study in areas appropriate to the interests and needs of students and staff.

300. Apprentice Teaching in Religion Studies (1-3) fall-spring

335. (SR 335) Religion, Symbolism and Cosmology (3) fall
How human experience is mediated through the use of symbols. Religious and cosmological systems in cross-cultural perspective. Frankel, Gatewood

355. (Hist 355) European Intellectual History. (3) fall
Political and religious thought and other aspects of the history of ideas in Europe from the Middle Ages to about 1700. Baylor

Russian

This language is associated administratively with the department of modern foreign languages. Therefore, the reader is referred to that entry in this section of the catalog for the description of Russian courses.

Russian Studies

See College of Arts and Science, Special Interdisciplinary Minors, Section III. For Russian languages and culture, see Modern Foreign Languages in the forepart of this section.

Social Relations

Professors. Linton C. Freeman, Ph.D.; Roy C. Herrenkohl, Ph.D.; Robert C. Williamson, Ph.D.
Associate professors. Robert E. Rosenwein, Ph.D., *chairperson;* Barbara B. Frankel, Ph.D., James R. McIntosh, Ph.D.
Assistant professor. John B. Gatewood, Ph.D.

Social relations combines three disciplines—anthropology, social psychology and sociology—within a single department. These disciplines have as their central and shared concern the understanding of human behavior in relationships, or more generally, theory and research in social settings. Yet while there is overlap, each discipline has an area of particular concern and interest on which it focuses: the study of "human nature" in the context of culture and cultural differences (anthropology), the study of the individual in the group (social psychology), and the study of larger social structures and institutions (sociology).

Students who sample broadly in these course offerings can learn among other topics, about the dynamics of small groups, human communication, prejudice, attitude change, social deviance, major social institutions such as family, social networks, conflict and conflict resolution, society and mental illness, the relation of the physical environment to social behavior, archaeology, specific cultural areas, such as American Indians and Oceania, alternative

community structures. Students who major in social relations may elect to concentrate in one of the three disciplines or create an interdisciplinary concentration. In any concentration, the students can expect to be exposed to theory and research in all three disciplines.

Graduates of this department, especially with some advanced training, can expect to find employment opportunities in both public and private areas. Combined with a major or minor in government, international relations, psychology, journalism, or religion studies, a concentration in one of the social relations disciplines provides a background for students interested in the law, communications, the ministry, the helping professions, and other careers where the understanding of human social behavior is important.

Social Work Program

Students interested in social work may take courses in the Social Work Education Program, a joint undertaking of the Lehigh Valley Association of Independent Colleges. This program exposes students to the kind of work which social workers do, and combines both theory and experience. Although not required, most students in this program major in social relations and take additional courses and fieldwork in other colleges in the consortium. For further information about this program, contact Dr. Robert C. Williamson in the social relations department.

Major Requirements

A student may elect one of four major concentrations. The concentration will be listed on the student's transcript.

Concentration in Anthropology
SR 211, 212 (6)
Anth 395 (3)
Anth 337 (3)
at least two courses from the following ethnographic courses
Anth 131, 151, 182, 184 (6); Clss 21, 22 (6)
at least two courses from the following topical courses
Anth 232, 335, 339, 363, 368, 376 (6)
one advanced course in sociology (3)
one advanced course in social psychology (3)
total required credit hours: 30

Concentration in Social Psychology
SR 211, 212 (6)
Soc. Psych 21 (3)
one sequence from the following (6)
Soc Psych 121 and 312 (small group sequence)
Soc Psych 72 and 311 (social ecology sequence)
Soc Psych 175 and 307 (attitudes and social influence sequence)
Soc Psych 35 and 308 (communications sequence)
two additional courses in social psychology (6)
one advanced course in anthropology (3)
one advanced course in sociology (3)
Psych 353 (3)
total required credit hours: 30

Concentration in Sociology
SR 211, 212 (6)
Soc 5 (3)
five upper divison sociology courses (15)
Of these fifteen credit hours, only three may be elected from the 100-199 sociology series. Three credits from a related discipline may be substituted.
one advanced course in social psychology (3)
one advanced course in anthropology (3)
total required credit hours: 30

Unstructured (Interdisciplinary concentration)
Students who are interested in creating an independent major combining elements from anthropology, social psychology and sociology should consult the department chairperson.

Requirements for the Minor

Anthropology: fifteen credit hours, including SR 211 and 212.
Social psychology: eighteen credit hours, including SR 211, 212 and Soc Psych 21
Sociology: eighteen credit hours, including SR 211, 212, and Soc 5.

Honors Option
A student may graduate with honors in any of these three major concentrations by completing an independent project supervised by one or more members of the faculty. Students who elect this option will be required to take a readings course (SR 371 or 372) and SR 399 (Senior Project). The chairperson should be consulted for further details.

Undergraduate Courses

Social Relations (Interdisciplinary)

41. Human Sexuality (3) P
Analysis of the socialization of sex roles and the life cycle, premarital and marital sex behavior, human reproduction and its control. Some attention to deviant sex roles. Williamson

211. Integrated Study of Social Relations (3) fall
Theory and methodology in analyses of social relations. Use of contemporary journals and other materials providing an introduction to requisite skills in anthropology, sociology and social psychology.

212. Integrated Study of Social Relations (3) spring
Continuation of SR 211. Prerequisite: SR 211.

368. The Urban Community (3) spring
A study of urban communities in the world and the United States. Theories of urban life and the special qualities of urban interaction. McIntosh or Frankel

371. Special Topics in Social Relations (1-3)
An opportunity for advanced work through supervised reading and research. Prerequisite: consent of the department chairman.

372. Special Topics in Social Relations (1-3)
Continuation of SR 371.

377. Computer Applications in Social Relations (3)
Computer applications in the social and behavioral sciences. Students learn a simple computer language and write programs in areas of personal interest. Freeman

395. Methods in Observation (3) alternate years
Naturalistic and participant observation in uncontrolled field settings. Frankel or Rosenwein

397-398. Independent Research (3-4)
Students will conduct research under faculty supervision. Prerequisite: consent of the department chairman.

399. Senior Project (3)
Independent work fulfilling major requirement. Prerequisite: SR 211-212, and consent of the department chairperson.

Anthropology

9. The Anthropological Enterprise (3) P
Comparing and contrasting different social and cultural versions of the world. What anthropologists do and how they think about what they do. Gatewood

33. Cutural Passages (3) P
Novels, travellers' accounts, and ethnographers' field work experiences; the role of human nature in transcending cultural differences. Cultural passages within one culture, e.g., initiation rites. Frankel or Gatewood

131. Science, Technology and Society (3)
Relationships of science and technology to social life across time and space, with alternative theoretical models for understanding these relationships. Frankel

151. Utopias and Alternative Communities (3)
Present and past searches for new forms of community in fact and fiction. Frankel

182. Aboriginal Cultures of North America (3)
Cultures in North America before European control. Principal subsistence strategies and forms of social organization of North American Indians. Gatewood

184. Cultures of the Pacific (3)
Cultures in the Pacific: prehistories, language families, and social organizations. Gatewood

232. (Clss 232) Principles of Archaeology (3)
Basic methods of prehistoric archaeology, with focus on problems shared with other branches of anthropology. Gatewood

335. (RS 335) Religion, Symbolism and Cosmology (3)
How human experience is mediated through the use of symbols. Religious and cosmological systems in cross-cultural perspective. Frankel or Gatewood

337. Anthropological History and Theory (3)
Major theoretical constructs used in anthropology in the context of their historic emergence. Frankel, Gatewood

339. Seminar in Anthropology (3)
Topics in anthropology. Varying from semester to semester: human evolution, politics and law, introduction to linguistics, human use of space, medical anthropology, anthropology of deviance. May be repeated for credit. Frankel, Gatewood

363. Kinship and Social Organization (3)
Kinship as the central institution in primitive social organization; consideration of theories accounting for the form of kinship systems. Soc 364, The Family, is recommended in conjunction with this course. Gatewood

376. Cognitive Anthropology (3)
Rise of the "individual" in culture theory; current anthropological interests in human cognition. Gatewood

Social Psychology

21. (Psych 21) Social Psychology (3) P
Theories, methods of investigation, and results of research in social psychology with emphasis on psychological processes in social behavior, social attitudes, group behavior, and social interaction. Not offered to students who have had SR 7.

35. Human Communication (3) P
Processes and functions of human communication in relationships and groups. Rosenwein

72. Social Environment (3) P
The influence of social phenomena on individual and group functioning. Social influences on individual development, health, emotional well-being and performance. Herrenkohl

121. Social Psychology of Small Groups (3)
Study of interpersonal behavior in groups. Survey of relevant theories and empirical research. Rosenwein

144. Social Psychology of Mental Illness (3)
Relationship of social psychological phenomena to mental illness: social influence, relationships in the family and other interpersonal aspects.

175. Intergroup Relations (3)
The relationships between social groups; intergroup conflict and cooperation. Herrenkohl

307. Attitudes and Social Influence (3)
An examination of the concept of attitude in social psychology and the determinants of attitude change. Attention to problems and issues in persuasive communication, propaganda, brainwashing, conformity, and other social processes.

308. Seminar in Social Psychology (3)
Intensive consideration of selected topics in current theory and research in social psychology. The subject matter varies from semester to semester, and includes such topics as the social psychology of education, the applications of perception and learning theory to social psychological problems, the social psychology of science, and the social environment of communication. May be repeated for credit.

311. Social Ecology (3) fall
Relationships between people and artificial environment. Architectural design, social organization, personal awareness of environment, and human needs for privacy, personal territory, or interpersonal space. Herrenkohl

312. Interpersonal Behavior in Small Groups (3)
Intensive consideration of theoretical and methodological issues in the analysis of the development of small groups. Rosenwein

313. Social Psychology of Education (3)
Effect of value systems, community structures, and social institutions on the educational process. Influence of family dynamics, peer groups, teacher-expectations, and social status in the individual's educational adjustment. Williamson

333. (Govt 333) Social Psychology of Politics (3)
Political behavior viewed from a psychological and social psychological perspective. Barner-Barry or Rosenwein

392. Social Psychology Research Seminar (3)
Advanced seminar in social psychological research methods: evaluation research and experimental social psychology. Recommended: SR 211 and 212, or Psych 113 and 114, or consent of the department chairperson. May be repeated once for credit. Herrenkohl, Rosenwein

Sociology

5. The Social System (3) P
Analysis of social organization emphasizing structure, function, stability and change.

51. Visual Sociology (3) P
Introduction to the use of the still camera as a tool for creating important social and sociological images. Development of the photo essay as a sociological reporting technique. Freeman

53. Popular Culture I (1) P first third of semester
Popular music in contemporary society. Freeman

55. Popular Culture II (1) P second third of semester
Film in contemporary society. Williamson

57. Popular Culture III (1) P last third of semester
Sports, including the role of play, in contemporary society. McIntosh

65. Contemporary Social Problems (3) P
Studies of major problems facing contemporary society. McIntosh

141. Social Deviance (3)
Analyses of deviant social systems, supporting factors maintaining them, and societal responses to deviant roles and collectivities. McIntosh

161. Sociology of Occupations (3)
Analysis of occupational choice, recruitment, training and socialization. Attention to the questions of the occupational professional continuum, the work setting, alienation, the relation of careers to various social organizations, the life cycle and demographic trends. Williamson

221. Mathematical Models of Social Networks (3) alternate years
Designed for students in physical science and engineering. Time-dependent process models of the structure of relationships among human beings. Prerequisite: at least one year of college mathematics. Freeman

314. (Mgt 314) Organization Structure and Communication (3) alternate years
Models of the formal and informal communication structures of

business, industrial and governmental organizations and the consequences of these structures on morale and productivity. Freeman

325. (Hist 325) American Social History, 1607-1877 (3) fall
Social change from early agrarian communities to beginnings of industrialism, emphasizing socio-economic class, family structure, and treatment of women and minority groups.

326. (Hist 326) American Social History Since 1877 (3) spring
Changing role of women, minority groups, and the family during the industrial era. Development of the modern class structure and the impact of the welfare state.

364. The Family (3) spring
A sociological study of man's basic institution. Includes an analysis of historical backgrounds, interactions within the family, relation to other groups and institutions, problems of family disorganization, legal aspects of marriage and divorce, family adjustment, and the family in a changing society. Anth 326, Kinship and Social Organization, is recommended in conjunction with this course. Williamson

365. Language and Society (3)
The development of language, subcultures, and problems of language maintenance, shift, planning and other aspects of sociolinguistics. Williamson

367. Change and Conflict in Latin America (3) fall
Introduction to the changing societies of Latin America including contrasts between urban and rural subcultures. Analysis of ethnic groupings and social institutions, especially family, school and church. Williamson

370. Juvenile Delinquency (3)
The development of delinquent behavior within its social context; an analysis of delinquent gangs and subcultures and the variable patterns of antisocial activity; and the evaluation of institutional controls and treatment of the problem. McIntosh

373. Seminar in Sociology (3)
Intensive consideration of selected topics in contemporary theory or research in sociology. The subject matter varies from semester to semester. May be repeated for credit.

374. Social Stratification (3)
Examination of concepts of stratification, such as social class, and of theories using these concepts. Consideration also of research findings which indicate the significance of stratification for society. Recommended: SR 211 or 212, or consent of the department chairperson.

375. Migration (3) alternate years
An examination of the bases for and consequences of human migratory movement. Emphasis on exploring process models of migration. Recommended: SR 211 and 212 or consent of the department chairperson. Freeman

381. Development of Sociological Theory (3)
A comparative study of principal schools of social theory with emphasis on the 20th Century. Critical analysis of selected sociological concepts.

385. Social Structure (3)
The theory of social structure considered as a basic key to the understanding of social phenomena, with attention to such concepts as interaction, position, role and role-set, status, institutionalization, equilibrium, norm, and culture. Selected propositions concerning structural relationships and processes will be examined. Recommended: SR 211 or 212, or consent of the department chairperson.

For Graduate Students

The department offers a master of arts degree program in social relations. This thirty-credit program offers both further preparation for an advanced degree and training for non-academic careers.

Students preparing for further study may elect a general program of studies or one which focuses on group dynamics and process. Students preparing for nonacademic careers may elect training in community social psychology/sociology/anthropology, which combines academic training and internship experience, or they may elect training in social science editing, which combines work on the journal *Social Networks* with courses in the department and the division of journalism.

Other options which focus on the research interests of specific faculty members are also available. The department in conjunction with the Center for Social Research offers many opportunities for research experience. For further information, students should contact the head of the graduate program.

411. Advanced Research Methods (3) fall
A basic course given in research theory and methods. Consideration given the nature of theory, hypotheses testing, the definition of variables and methods of measurement. Herrenkohl

412. Practicum in Research Methods (3) spring
Laboratory in the design and execution of research. Emphasis on the design of measurement instruments, the application of statistical techniques, and the analysis and interpretation of data. The student pursues an independent research project and writes a research report based on it. Prerequisite: SR 411.

423. Social Psychology (3)
An examination of theory and research in social psychology. The objective of the course is to consider major topics and issues in relation to current research. Rosenwein

464. Seminar on the Family (3)
Societal functions of marriage and the family and the relation of the institution to the social structure and demographic variables. Particular emphasis on the treatment of family disorganization. Williamson

465. Organizational Behavior (3)
Theory and research concerning the development and functioning of organizations. Structure, goals, authority and power, communication, role conflict in large organizations. Cross-institutional comparisons of industrial research, governmental, medical and academic organizations.

468. Advanced Urban Sociology (3)
Selected problems in urban research, urban and community planning and redevelopment. Relation of the city and the region to economic development and governmental functions. McIntosh

470. Social Theory (3) fall
Major trends in social science theory in historical context. Comparison of the major theoretical perspectives with an emphasis on underlying philosophy and the development of critical capacities in students.

471. Special Topics (1-3)
Intensive study in an area of social relations which is appropriate to the interests and needs of staff and students.

472. Special Topics (1-3)
Continuation of SR 471.

Spanish

Spanish courses are offered in the department of modern foreign languages. Therefore, the reader is referred to that entry in the forepart of this catalog for descriptions of courses.

Speech and Theater

Speech and Theater is associated administratively with the department of English. Therefore, the reader is referred to that entry in the forepart of this section for courses.

Urban Studies

Urban Studies Committee. David Curtis Amidon, Jr., M.A., lecturer in urban studies and *director* of urban studies; Nicholas Adams, Ph.D., assistant professor and chairman of art and architecture; Carlos J. Alvare, M.C.P., M. Arch., associate professor of architecture; Frank T. Colon, Ph.D., associate professor of government; James R. McIntosh, Ph.D., associate professor of sociology; Edward P. Morgan, Ph.D., assistant professor of government; Warren A. Pillsbury, Ph.D., associate professor of economics; Roger D. Simon, Ph.D., associate professor of history.

Undergraduate Major

This is an interdepartmental major program intended for students who seek a broad background in the social sciences and for those with career interests in such fields as city management, architecture and urban planning, human relations, and the helping professions.

Instruction focuses on the process of urbanization, the problems and opportunities arising therefrom, analytical methods and insights which have been developed by students of urbanization, and existing and proposed public policies relating to cities.

A minimum of forty-two credit hours is required, apportioned among three levels of study. Substitutions are possible with approval of the director, who advises all those with majors and minors in urban studies. No course can be used to satisfy requirements at more than one level.

I. required preliminary courses (9 credit hours)

US 61	The Study of Urbanization (3)
US 62	Contemporary Urban Issues (3)

one of the following four research methods courses

SR 211	Integrated Study of Social Relations (3)
Govt 21	Introduction to Political Research (3)
Hist 395	Quantitative Methods in Historical Studies (3)
Eco 45	Statistical Method (3)

II. required core courses (18 or 19 credit hours)
choice of three of the following five sequences

economics sequence

Eco 1	Economics (4)
Eco 312	Urban Economics (3)

architecture sequence

Arch 151	History of Urban Design (3)
Arch 152	Physical Planning and Design (3)

government sequence

Govt 77	Urban Politics (3)

and any one of these

Govt 328	Politics of Urban Policy (3)
Govt 331	Internship Seminar (3)
Govt 360	Public Administration (3)

history sequence

Hist 333	American Urban History to 1880 (3)
Hist 334	American Urban History, 1880 to Present (3)

social relations sequence

SR 211	Integrated Study of Social Relations (3) *or*
SR 212	may be substituted if SR 211 has been used to satisfy the research methods preliminary requirement above.
Soc 368	The Urban Community (3)

III. area option courses (15 or more credit hours)
One of the following four area options is elected for a minimum of five courses yielding at least fifteen credit hours.

A. *urban management option* (15 credit hours)
Prerequisites: three core sequences above, including economics and government.

Acctg 108	Fundamentals of Accounting (3)
Eco 337	Transportation and Spatial Economics (3)
Eco 354	Public Finance: State and Local (3)
Govt 331	Internship Seminar (3)
Govt 354	Administrative Law (3)
Govt 360	Public Administration (3)
Law 202	Business Law (3)
Mgt 321	Business and Organizational Behavior (3)

B. *urban design option* (15 credit hours)
Prerequisites: three core sequences above, including architecture and history

Eco 337	Transportation and Spatial Economics (3)
Arch 43	Introduction to Architectural Design (4)
Arch 143	Intermediate Architectural Design I (3)
Arch 144	Intermediate Architectural Design II (3)
Arch 145	Architectural Structures (3)
Arch 207	Renaissance Architecture (3)
Arch 209	Architecture 1750-1880 (3)
Arch 210	20th-Century Architecture (3)
Geol 211	Environmental Geology (3)

C. *social science option* (15 credit hours)
Prerequisites: three core sequences above; courses not offered to satisfy the core sequences requirement may be included below.

Eco 311	Environmental Economics (3)
Eco 337	Transportation and Spatial Economics (3)
Eco 354	Public Finance: State and Local (3)
Hist 326	American Social History Since 1877 (3)
Hist 331	The Negro in America (3)
Hist 339	Public Health in America (3)
Clss 204	The Ancient City (3)
Anth 151	Utopias and Alternative Communities (3)
Arch 207	Renaissance Architecture (3)
Arch 209	Architecture 1750-1880 (3)
Arch 210	20th-Century Architecture (3)
MFLL 102	Great Cities (3)
US 363	Philadelphia: Development of a Metropolis (3)
US 365	Lehigh Valley: Development of a Regional Center (3)

or up to two additional US courses (3-6)

D. *human relations option* (15 credit hours)
Prerequisites: three core sequences above, including social relations. Of the total of fifteen credit hours for this option, at least six credit hours must be elected from among the courses in each group below:

Cultural groups

US 125	American Ethnic Groups (3)
US 321	White Protestant Americans (3)
US 324	The Irish in American Society (3)
US 326	The American Italian Community (3)
US 328	The American Jewish Community (3)
Engl 312	Jewish Literature (3)
Engl 316	The Indian in American Literature (3)
Engl 319	The Black in American Literature (3)
German 233	Pennsylvania German Culture (3)
RS 151	The Jewish-Christian Encounter (3)
RS 153	Religion and the American Experience (3)
RS 154	The Holocaust (3)
Hist 325	American Social History, 1607-1877 (3)
Hist 326	American Social History Since 1877 (3)
Hist 331	The Negro in America (3)

professional concepts

Govt 328	Politics of Urban Policy (3)
Govt 331	Internship Seminar (3)
Govt 352	Civil Rights (3)
Soc Psy 35	Human Communication (3)
Soc 365	Language and Society (3)
Soc 370	Juvenile Delinquency (3)
Soc 375	Migration (3)

Note that six credit hours in the professional concepts category toward the human relations option will be allowed students who

complete a major program in social welfare education through the Lehigh Valley Association of Independent Colleges, provided that major credit is not also claimed for Govt 331.

Urban Studies Minor

The minor consists of US 61 and five additional courses from an approved list for a total of eighteen credit hours.

Undergraduate Courses

61. The Study of Urbanization (3) fall
Analyses of the city from early historical speculations to current behavioral studies.

62. Contemporary Urban Issues (3) spring
Review of the literature on urban issues: poverty, law enforcement, race relations, planning and education.

125. American Ethnic Groups (3) fall 1980
Immigration to the United States; persistence of cultural differences over generations; patterns of conflict and accommodation; assimilation; ethnic politics; emphasis on white Euro-American nationality groups; with some attention to Afro-, Hispano-, Asian- and native Americans. Amidon

300. Apprentice Teaching (3)
Opportunity for selected seniors to assist in all aspects of instruction, usually in US 62, under close supervision. Prerequisite: consent of the program director.

321. White Protestant Americans (3) fall 1979
Cultural and religious origins of the historically dominant ethnic group in the United States; rise and decline of a national Anglo-Protestant urban elite; persistence of regional and non-elite subcultures; "Wasp" sterotypes and anti-Protestant themes in American culture. Amidon

324. The Irish in American Society (3) spring 1981
Cultural, economic and political experience of a major white ethnic group in the United States; Irish Catholics vs. Scotch-Irish Protestants; immigrant poverty; priests and prelates, ward healers and big-city bosses; Irish themes in American literature, humor and media culture; Irish radicalism. Amidon

326. The American Italian Community (3) spring 1980
European background of Italian emigration; patterns of first-generation experience in the United States; distinctive values, folkways and institutions; the "Mafia"; political behavior; upward mobility and assimilation; achievements of outstanding individuals; interaction with general American culture. Amidon

328. The American Jewish Community (3) spring
Historical and sociological perspectives on the experience of an important minority in the United States; communal institutions and social patterns; orientation toward achievement and secular success; Jewish influences in American culture; anti-Semitism, acceptance, and survival as a distinct subculture. Amidon

363. Philadelphia: Development of a Metropolis (3) fall
Philadelphia as an early experiment in the deliberate creation of a new community; the rise of the port; industrialization and immigration; creation of a hinterland and competition with rival centers; upper-class family continuity; religious life and institutions; political history; the Afro-American experience and the black impact on Philadelphia; "planning".

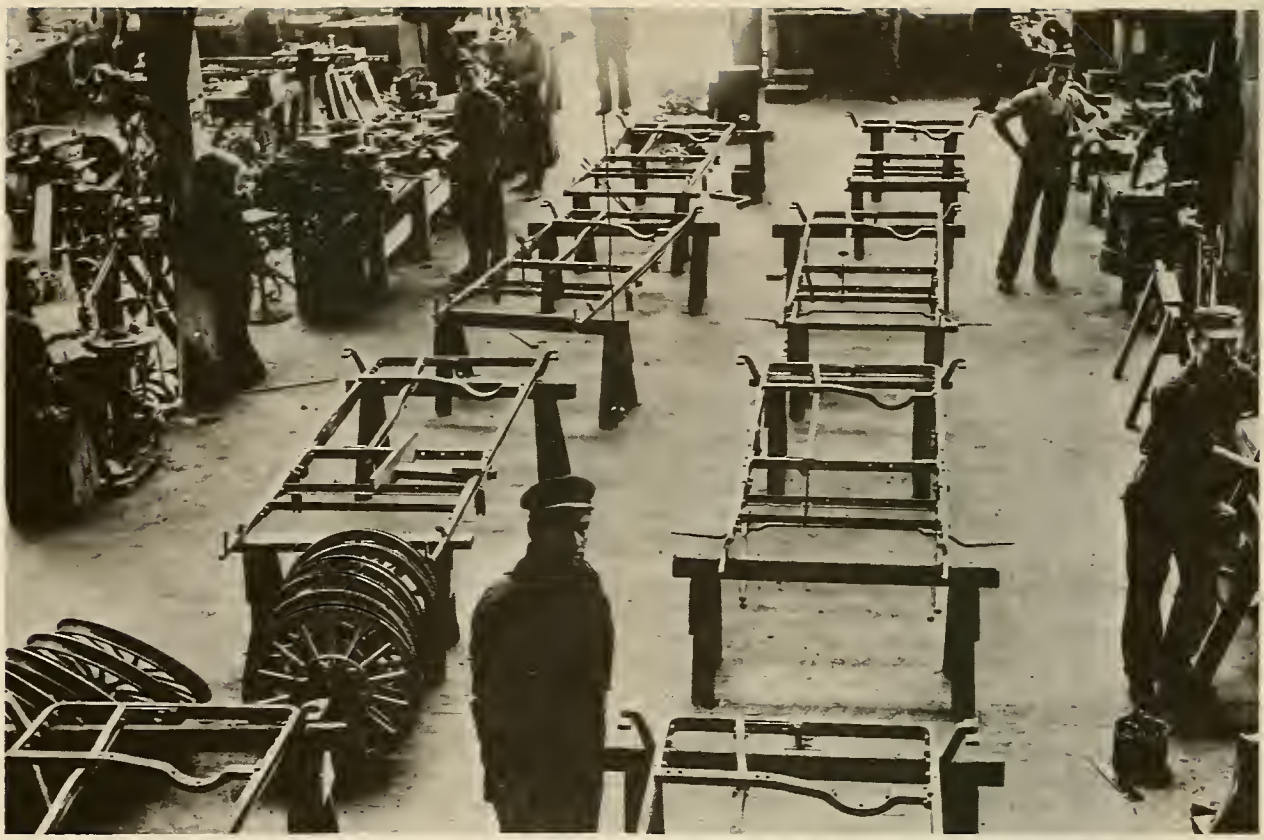
365. Lehigh Valley: Development of a Regional Center (3) summer
Analysis of the growth and character of regional centers ("provincial towns") in general; geography of the Lehigh Valley; development of the economic, cultural and political characteristics of this area; public policy in such areas as economic development, physical planning, social welfare and human relations. Primarily for summer session, but may occasionally replace US 363 in the fall.

371. Special Topics (3)
A seminar on a topic of special interest in urban studies. Prerequisite: consent of the program director.

372. Special Topics (3)
Same as US 371.

For Graduate Students

An urban studies option is offered under the master of public administration (MPA) degree which is administered by the department of government.



Horsepower and sawhorse were closely related in this very early Packard assembly line in the days when every automobile was built entirely by hand.

VI. Who's Who at Lehigh

This section lists the people whose talents and abilities constitute the university's most important resource. Subsections include the board of trustees who contribute their expertise to establish the policies of the university; the administration; members of the faculty and staff; and, finally, the members of the visiting committees who help to keep courses of instruction current and of maximum value to the students and prospective employers.

Board of Trustees

When the year of the degree is listed, the degree was awarded by Lehigh University.

Officers of the Board

Harold S. Mohler, president
Elmer W. Glick, honorary secretary
John W. Woltjen, secretary and treasurer
Paul J. Franz, Jr., assistant secretary

Corporate Members

William B. Eagleson, Jr., B.S. '49, M.B.A., '51; chairman and chief executive officer, Girard Bank, Philadelphia.

Edwin H. Gott, B.S. '29, Eng.D. '68, Sc.D., LL.D.; director, chairman of the board (retired), United States Steel Corporation.

William C. Hittinger, B.S. '44, Eng.D.; executive vice president, research and engineering, RCA Corporation.

C. Lester Hogan, B.S., M.S. '47, Ph.D. '50, Hon. A.M., Eng.D., D.Sc., Eng.D. (Hon.); vice chairman, Fairchild Camera and Instrument Corporation.

Walter S. Holmes, Jr., B.S. '41, M.B.A.; chief executive officer and chairman, C.I.T. Financial Corporation.

Harold S. Mohler, B.S. '48, LL.D. '75; chairman of the board and chairman of the executive committee, Hershey Foods Corporation.

Kirk P. Pendleton, B.S., B.A. '63; executive vice president, Pitcairn, Incorporated.

Frank C. Rabold, B.S. '39, Eng.D. '70; manager of corporate services, Bethlehem Steel Corporation.

Donald B. Stabler, B.S. '30, M.S., LL.D. (Hon.) '74; president and chairman, Stabler Companies, Incorporated.

The Rt. Rev. Dean T. Stevenson, B.A. '37, M.A. '49, S.T.B. '40, S.T.D., D.D. '69; bishop, Episcopal Diocese of Central Pennsylvania.

Corporate Members Emeriti

Andrew E. Buchanan, Jr., Ch.E. '18, Eng.D.; general manager (retired), E. I. du Pont de Nemours & Company.

Edward A. Curtis, B.S. '26, LL.B., LL.D.; vice president for public affairs (retired), New Jersey Bell Telephone Company.

Allen C. DuBois, B.A. '25, LL.D.; partner (retired), Wertheim & Company.

Leonard M. Horton, B.S. '28, LL.D.; chairman of the board (retired), Aubrey G. Lanston & Company, Incorporated.

Kenneth L. Isaacs, M.E. '25, M.B.A., LL.D; consultant, chairman of the board of trustees (retired), Massachusetts Investors Trust.

Frank L. Magee, E.E. '17, Eng.D., LL.D.; chairman of the executive committee (retired), Aluminum Company of America.

Hugh P. McFadden, B.A. '25, LL.B., LL.D.; of counsel, Kolb Holland & Taylor.

Ivor D. Sims, B.S. '33, LL.D. '70; executive vice president (retired), Bethlehem Steel Corporation.

Edwin H. Snyder, E.E. '23, Eng.D. '68; board chairman and chief executive officer (retired), New Jersey Public Service Electric & Gas Company.

Members Elected by Alumni

The year in parentheses indicates when the term expires.

Gerald E. Berger, B.S. '71; Finance Department, Consolidated Rail Corporation. (1980)

Morgan J. Cramer, former president, P. Lorrilard & Company. (1979)

Samuel W. Croll, Jr., B.S. '48; president, Croll-Reynolds Company, Inc. (1984)

Milton H. Grannatt, Jr. B.S. '39; president, Fell & Moon Company. (1980)

Reginald A. Jennings, B.A. '70, J.D.; partner, Pickett & Jennings. (1979)

Stanley M. Richman, B.S. '55; vice president, Lightning Electric Company. (1982)

Robert H. Riley, Jr., B.S. '35; director of research, Black & Decker Manufacturing Company. (1983)

Charles E. Swenson, B.S. '51; partner, Swenson & Associates. (1981)

Appointed Trustees

The year in parentheses indicates when the term expires.

Dexter F. Baker, B.S. '50, M.B.A.; president, Air Products & Chemicals, Inc. (1979)

Malcolm Carrington, Jr., B.S. '39; vice president and secretary, New Jersey Public Service Electric and Gas Company. (1980)

Lee A. Iacocca, B.S. '45, Eng.D. '69; president, Chrysler Corporation. (1980)

Frank G. Kear, E.E. '26, S.M., Sc.D.; partner (retired), Kear & Kennedy. (1979)

Nancy M. Kissinger, B.A., M.S., D.H.L. '77. (1984)

Edwin F. Scheetz, Jr., B.S. '54; president, Moore, Leonard & Lynch, Inc. (1983)

Frederick Seitz, A.B., Ph.D., LL.D. '66; president emeritus, The Rockefeller University. (1982)

Richard M. Smith, B.S. '48; vice chairman, Bethlehem Steel Corporation. (1981)

James H. Walker, B.A., M.B.A.; vice president, finace (retired), Bethlehem Steel Corporation. (1981)

Honorary Trustees

Alfred G. Blake, C.E. '25; chairman of the board (retired), and director emeritus, Engelhard Minerals & Chemicals Corporation.

Edmund F. Martin, M.E., Eng.D., LL.D. '67; chairman of the board and chief executive officer (retired), Bethlehem Steel Corporation.

S. Murray Rust, Jr., B.S. '34; chairman of the board (retired), Rust Engineering Company.

Ralph L. Wilson, El.Met. '21, L.H.D. '68; director of metallurgy (retired), Timken Roller Bearing Company.

In Memoriam

It is with great regret that the university records the loss of a member of the board of trustees. Years of service as a trustee are noted.

H. Randolph Maddox, M.E. '21; vice president (retired), American Telephone and Telegraph Company (1953-1972; emeritus 1972-1977), died May 20, 1977.

Committees of the Board

Executive committee. Harold S. Mohler, chairman; Donald B. Stabler, first vice chairman; Edward A. Curtis, second vice chairman; Frank C. Rabold; Kirk P. Pendleton.

Physical planning and plant committee. Edward A. Curtis, chairman; Frank C. Rabold, vice chairman; Edwin H. Gott; Milton H. Grannatt, Jr.; Donald B. Stabler.

Committee on finance and investments. James H. Walker, chairman; Jack Barnett; Walter W. Buckley, Jr.; William B. Eagleson, Jr.; Walter S. Holmes, Jr.; Leonard M. Horton; Kirk P. Pendleton; Richard M. Smith.

Development committee. Donald B. Stabler, chairman; Alfred G. Blake; Edwin H. Gott; Walter S. Holmes, Jr.; Philip Rauch; Richard M. Smith; George G. Zipf.

Committee on membership. Harold S. Mohler, chairman; Edward A. Curtis, vice chairman; Walter S. Holmes, Jr.; Donald B. Stabler; James H. Walker.

Committee on bequests and trusts. Alfred G. Blake, chairman; Thomas G. Conley; Walter M. Diener; John L. Hetrick; Walter S. Holmes, Jr.; John K. Killmer; Robert H. Littner; Samuel J. Macri; Vincent J. Pazzetti, III; Robert S. Taylor, Jr.; Charles K. Zug.

Committee for visiting committees. Donald B. Stabler, chairman; Dexter F. Baker; Morgan J. Cramer; Stephen F. Goldmann, Kirk P. Pendleton.

Audit committee. Walter S. Holmes, Jr., chairman; Dexter F. Baker; Malcolm Carrington, Jr.; John B. O'Hara; Donald J. Wikstrom.

Succession committee. Harold S. Mohler, chairman; William C. Hittinger, Kirk P. Pendleton; Richard M. Smith; the Rt. Rev. Dean T. Stevenson.

The Visiting Committees

The university is eager to strengthen fruitful communication with the society which it serves, and that desire motivated the establishment of visiting committees of the board of trustees.

These committees annually bring to the university representatives of industry, government, and education who study those areas of the university which they are most competent to judge, and report periodically on their evaluation of those areas.

Members of the board of trustees often serve as chairmen of the visiting committees. In most cases, the first member listed is the chairman.

Those who are Lehigh alumni are indicated by the inclusion of their class year.

Athletics

Morgan J. Cramer, '28, retired president, P. Lorillard & Company

Curtis F. Bayer, '35, retired vice president, Erie-Lackawanna Railroad

Milton H. Grannatt, '39, president, Fell & Moon Company

Mark Parseghian, '49, president, Clarence B. Haney, Inc.

Keith C. Rust, '57, president, Roland & Roland, Inc.

James B. Swenson '59, tax partner, Price Waterhouse and Co.

Edward A. Curtis, '25, honorary member

Art and Architecture

Lucille Bunin Askin, art lecturer

Louis Stoumen, department of theater arts, University of California

J. B. Jones, associate, The Architects Collaborative, Inc.

John Coolidge, department of fine arts, Fogg Museum, Harvard University

Biology

Frank C. Rabold, '39, manager of corporate services, Bethlehem Steel Corporation

John P. Barlow, professor of ecology and systematics, Cornell University

Fred Rapp, chairman of microbiology, Pennsylvania State University Medical Center

Robert E. Ricklefs, professor of biology, University of Pennsylvania

Robert Saydah, '49, director of marketing, Lederle Laboratory and Pharmacy Division of American Cyanamid Company

Samuel G. Siris, '67, physician, State Psychiatric Institute of New York

Business and Economics

Morris Goldstein, '34, president, M. G. Foundation, Inc.

John C. Archibald, '54, executive vice president, Chase Manhattan Bank

James R. Bright, '39, president, Industrial Management Center

Eugene E. Mercy, '59, partner, Goldman Sachs and Company

Philip Peller, '60, partner, Arthur Andersen & Company

Philip Rauch, '33, chairman of the executive committee, Parker Hannifin Corporation

Center for the Application of Mathematics And Department of Mathematics

Richard M. Smith, '48, vice chairman, Bethlehem Steel Corporation

Hyman Bass, professor of mathematics, Columbia University

Laurence B. Heilprin, School of Library and Information Services, University of Maryland

Daniel H. Wagner, president, Daniel H. Wagner Associates

Chemical Engineering

Alfred G. Blake, '25, director emeritus, Engelhard Minerals & Chemicals Corp.

C. C. Baldwin, '50, vice president, Stauffer Chemical Company

Robert B. Beckmann, dean, College of Engineering, University of Maryland

P. L. T. Brian, vice president of corporate engineering, Air Products & Chemicals, Inc.

Elton J. Cairns, assistant head, electrochemistry department, General Motors Corporation

Stephen F. Goldmann, '66, marine department, Exxon Corporation

Gary Kohler, '67, investment planner, Exxon Corporation

R. E. Siegfried, '43, president, The Badger Company, Inc.

Chemistry

Donald C. Oskin, '39, executive vice president, FMC Corporation

Tomlinson Fort, Jr., professor and head of the department of chemical engineering, Carnegie-Mellon University

Nelson J. Leonard, '37, professor of chemistry, University of Illinois, Urbana-Champaign

Charles N. Reilley, professor of chemistry, University of North Carolina

Earl J. Serfass, '38, president, Sercon Corporation

Civil Engineering

Donald B. Stabler, '32, president and chairman, Stabler Companies, Inc.

Ven T. Chow, department of civil engineering, University of Illinois

John R. Kiely, executive consultant, Bechtel Corporation

T. William Lambe, department of civil engineering, Massachusetts Institute of Technology

Francis C. Turner, consulting engineer, Arlington, Va.

Classics

Daniel G. Gambet, O.S.F.S., president, Allentown College of St. Francis de Sales

John A. Anderson, chairman, department of humanities, The Hill School

Walter Donlan, professor, department of classics, Pennsylvania State University

Helen F. North, professor of classics, Swarthmore College

Computing and Information Science And Computing Center

Leonard R. Dimmick, '49, general manager, corporate data processing, Bethlehem Steel Corporation

Weston J. Burner, director, Information Processing Center, Massachusetts Institute of Technology

John E. Creps, Jr., executive director, Engineering Index, Inc.

Raffee Ellis, director, Computing Center, University of Pittsburgh

Michael J. Levine, department of physics, Carnegie-Mellon University

Paul J. Plourde, director, Three College Computer Center, Amherst College

Vladimir Slamecka, director, School of Information and Computer Service, Georgia Institute of Technology

Electrical Engineering

William C. Hittinger, '44, executive vice president, research and engineering, RCA Corporation

Lester F. Eastman, professor of electrical engineering, Cornell University

Paul C. Ely, Jr., '53, vice president, Computer Systems Group, Hewlett-Packard Corporation

Gerald B. Herzog, staff vice president, RCA Corporation

John E. Mack, '51, director, Bell Telephone Laboratories

James L. Massey, professor of system science, University of California at Los Angeles

Edwin H. Snyder, '23, honorary member

English

Rodger V. Digilio, '65, president, OTV, Inc.

Robert J. Cochnar, '61, editor, San Jose Mercury News

William Digel, '63, editor, E. I. du Pont de Nemours & Company

Virgie E. Granger, department of English, William Paterson College of New Jersey

Peter Wolfe, '57, department of English, University of Missouri, St. Louis

Geological Sciences

S. Murray Rust, Jr., '34, retired chairman, Rust Engineering Company

Melvin J. Hill, president, Gulf Oil Exploration and Production Company

Lawrence H. Lattman, dean, College of Mineral Sciences, University of Utah

Siegfried J. Muessig, manager, mineral exploration, Getty Oil Company

Richard B. Palmer, '43, senior vice president, Texaco, Inc.

Roland Von Huene, Office of Marine Geology, U.S. Geological Survey

Government

Gordon B. Mowrer, '65, Hampson-Mowrer Agency

John N. Hazard, '70 (Hon.), professor of law, Columbia School of Law

Joseph V. Julian, vice president for public affairs, Syracuse University

Theodore J. Lowi, Joshn L. Senior Professor of American Institutions, Cornell University

Maury B. Poscover, '66, Husch, Eppenberger, Donohue, Elson and Cornfield

Dankwart Rustow, distinguished professor of political science, City University of New York

Edward A. Curtis, '26, trustee liaison

Center for Health Sciences

Burton J. Bogitsh, department of biology, Vanderbilt University

Peter Brueckner, Sunnybrook Medical Center, University of Toronto

William C. Campbell, director of research, Merck Institute for Therapeautic Research

Howard Morgan, Hershey Medical Center, Pennsylvania State University

Robert M. Nerem, associate dean, Graduate School, Ohio State University

John Russell, vice president, hospital services, Hospital Association of Pennsylvania

History

Reginald A. Jennings, '70, partner, Pickett & Jennings

Robert F. Byrnes, department of history, Indiana University

John Duffy, department of history, University of Maryland

Mary M. Dunn, department of history, Bryn Mawr College

Vartan Gregorian, dean of the faculty of arts and science, University of Pennsylvania

Brooke Hindle, senior historian, Smithsonian Institution

Merrill D. Peterson, department of history, University of Virginia

Otey M. Scruggs, department of history, Syracuse University

Industrial Engineering

Everett H. Van Hoesen, '55, president, Information Records Division, IBM Corporation

Arnold O. Putnam, '43, president, Rath & Strong, Inc.

Paul Torgersen, '53, dean, College of Engineering, Virginia Polytechnic Institute

William L. Westerman, '54, president, Cellu-Craft Inc.

George G. Zipf, '42, vice chairman, J. Ray McDermott Co., Inc., and president, Babcock & Wilcox Co.

International Relations

Frederick Seitz, '66 (Hon.), president emeritus, The Rockefeller University

Percy E. Corbett, '73 (Hon.), retired professor emeritus

William S. McConnor, '41, president, Union Oil Center

Joseph V. Montville, '59, regional policy adviser, Department of State, Washington, D.C.

Alvin Z. Rubenstein, department of political science, University of Pennsylvania

Marshall Shulman, Russian Institute, Columbia University

Library

C. Lester Hogan, '50, vice chairman, Fairchild Camera and Instrument Corp.

Connie Dunlap, director of libraries, Duke University

Jay K. Lucker, director of libraries, Massachusetts Institute of Technology

Thomas H. Mott, dean, Graduate School of Library Science, Rutgers University

Carlton Rochelle, director of libraries, New York University

Laurence Fenninger, Jr., retired vice president for public affairs, Bethlehem Steel Corporation, honorary member

David Kaser, professor, Graduate School of Library Science, Indiana University, honorary member

W. Kenneth Lowry, manager, Technical Information Library, Bell Telephone Laboratories, honorary member

Center for Marine and Environmental Studies

Joseph A. Mihursky, '62, professor, Natural Resources Institute, University of Maryland

John D. Costlow, director, Duke University Marine Laboratory

Terry Edgar, deputy division chief, U.S. Geological Survey

William S. Gardner, president, Woodward-Clyde Associates

Roy F. Weston, president, Roy F. Weston, Inc.

Mechanical Engineering and Mechanics

Dexter F. Baker, '57, president, Air Products & Chemicals, Inc.

Raymond Cohen, director, Herrick Laboratories, Purdue University

John W. Hutchinson, '60, department of applied physics and engineering, Harvard University

Hustace Hubbard Poor, vice president for research and development, Babcock & Wilcox Company

Norman D. Postma, executive engineer, Ford Motor Company

Herbert Richardson, director, mechanical engineering department, Massachusetts Institute of Technology

Robert J. Sanator, senior vice president, Fairchild Republic Company

Metallurgy and Materials Engineering And Materials Research Center

Edward H. Kottcamp, '60, director, Homer Research Laboratories, Bethlehem Steel Corporation

Michael V. Nevitt, deputy laboratory director, Argonne National Laboratory

Harold D. Brody, chairman, department of metallurgy and materials engineering, University of Pittsburgh

Gilbert Y. Chin, head, physical metallurgy and ceramics development department, Bell Telephone Laboratories

Modern Foreign Languages

Dean T. Stevenson, '37, bishop, Episcopal Diocese of Central Pennsylvania

Hannah E. Bergman, professor, City University of New York

Edward D. Sullivan, professor of French, Princeton University

Michael Toconita, professor of modern languages, St. Joseph's University

Music

Kenneth L. Houck, retired

John Heiss, New England Conservatory of Music

Philosophy

Dean T. Stevenson, '37, bishop, Episcopal Diocese of Central Pennsylvania

Peter Achinstein, chairman, department of philosophy, Johns Hopkins University

Frederick Ferre, department of philosophy, Dickinson College

Joseph Margolis, department of philosophy, Temple University

Judith Thomson, department of philosophy, Massachusetts Institute of Technology

Physics

William Fleckenstein, '49, vice president, Bell Telephone Laboratories

Hollis Caswell, director of applied research, IBM

Robert S. Knox, '53, department of physics and astronomy, University of Rochester

Robert G. Wheeler, '50, department of engineering and applied science, Yale University

Rennos Zaphiropoulos, '47, president, Versatec

Psychology

Stanley Richman, '55, vice president, Lightning Electric Company

Ernest J. Keen, department of psychology, Bucknell University

John Krauskopf, Bell Telephone Laboratories

Wilbert J. McKeachie, department of psychology, University of Michigan

Real Estate

James H. Walker, retired

George F. Bloom, professor of real estate administration, Indiana University

John P. Moran, vice president for facilities, Princeton University

Thomas F. Murray, executive vice president and chief investment officer, The Equitable Life Assurance Society of the United States

Richard Rauch, president, Rauch & Company

Religion Studies

Kirk P. Pendleton, '64, executive vice president, Pitcairn, Inc.

Thomas Hopkins, department of religion, Franklin and Marshall College

Howard C. Kee, School of Theology, Boston University

Benjamin Minifie, '33, retired rector

D. B. Robertson, department of religion, Syracuse University

Residence

Milton S. Grannatt, '39, president, Fell & Moon Company

Augusta Succop Betzwieser, '75, credit representative, U.S. Steel Corporation

Jan Clifford Phillips, '66, project engineer, Pennsylvania Power and Light Company

Stanley M. Richman, '55, vice president, Lightning Electric Company

School of Education

Malcolm Carrington, Jr., '39, vice president and secretary, Public Service Electric and Gas Company

Bruno Bettelheim, retired psychologist and author

Alden Dunham, program officer, Carnegie Corporation

Gene V. Glass, director, Laboratory of Education Research, University of Colorado

Elizabeth Koppitz, psychologist, Board of Cooperative Educational Services

Jack MacDonald, president, Motors Insurance Company

Ewald Nyquist, retired commissioner, New York State Department of Education

Philip H. Phenix, professor of philosophy and education, Columbia University

William Smith, director, Teachers Corps, U.S. Office of Education

Social Relations

Charles Swenson, '51, chairman, Swenson Associates

Harry C. Bredemeier, chairman, department of sociology, Rutgers University

James Fernandez, department of anthropology, Princeton University

Robert Krauss, department of psychology, Columbia University

Center for Social Research

Jack Fisher, director, Center for Metropolitan Planning and Research, Johns Hopkins University

Harriet L. Barr, director of research and evaluation, Eagleville Hospital and Rehabilitation Center

Victor Rabinowitch, staff director, Board of Science and Technology for International Development, National Academy of Science

James H. Walker, retired vice president for finance, Bethlehem Steel Corporation

Speech and Theater

Irvin Feld, '76 (Hon.), president, Ringling Bros. & Barnum & Bailey Combined Shows, Inc.

Lucille Bunin Askin, art lecturer

Arnold I. Bramow, '71, assistant to the president, Ringling Bros. & Barnum & Bailey Combined Shows, Inc.

Edward Cole, professor emeritus of drama, Yale School of Drama

Center for Surface and Coatings Research

Edward B. Uhl, '40, chairman and chief executive officer, Fairchild Industries

Elwood Backensto, '43, manager, materials engineering, Mobil Research and Development Corp.

Bohdan Burachinsky, vice president, research and development, Inmont Corp.

Egon Matijevic, Institute for Colloid and Surface Science, Clarkson College

Russell Rowlett, editor, Chemical Abstracts Service, Ohio State University

Robert W. Upson, retired general director of research and development, E. I. du Pont de Nemours & Co.

William S. Woodside, '47, president, American Can Company

Seward E. Beacom, consulting member

Members of the Administration

Complete degree information for all university administrators may be found in the alphabetical listing of faculty and staff, which follows this section. Only the highest degrees received are given here.

Offices of the President and Provost

Deming Lewis, Ph.D., LL.D., L.H.D., D.Eng., president
Albert C. Zettlemoyer, Ph.D., D.Sc., LL.D., provost and vice president
Paul J. Franz, Jr., M.A., vice president for development
Joseph F. Libsch, Sc.D., vice president for research
Eric V. Ottervik, Ph.D., vice president for planning and services
Preston Parr, M.S., dean and vice president for student affairs
Richard M. Spriggs, Ph.D., vice president for administration (on leave 1979)
John W. Woltjen, B.S., vice president and treasurer
Austin Gavin, LL.B., executive consultant
Nan Van Gieson, Ed.D., assistant provost
Mary I. Malone, B.A., secretary to the president

Academic Offices

John J. Karakash, M.S., D.Eng., dean of the College of Engineering and Physical Sciences
Robert D. Stout, Ph.D., dean of the Graduate School
Richard W. Barsness, Ph.D., dean of the College of Business and Economics
John W. Hunt, Ph.D., dean of the College of Arts and Science
Norman P. Melchert, Ph.D., associate dean, College of Arts and Science
Curtis W. Clump, Ph.D., associate dean, College of Engineering and Physical Sciences
Arthur F. Gould, M.S., associate dean, College of Engineering and Physical Sciences
Max D. Snider, M.B.A., associate dean, College of Business and Economics
Norman H. Sam, Ed.D., director, summer session
James A. Brown, Ph.D., director, continuing education
David Curtis Amidon, Jr., M.A., secretary of the faculty

Office of the Dean of Students

William L. Quay, Ph.D., dean of students
Arthur H. Mann, S.T.B., associate dean of students
Robert F. Reeves, M.A., associate dean of students
Muriel Whitcomb, M.A., assistant dean of students
Nathan W. Harris, B.S., assistant dean of students
Hershel L. Dorney, M.Ed., assistant to the dean of students
Barbara Kreppel, B.A., acting director of residence operations
Theodore A. Brent, M.S., Arlene Vernon-Oehmeke, M.Ed., and Robert M. Lospinoso, M.Ed., residence area coordinators

Office of the Registrar

James H. Wagner, M.A., registrar
Claire C. Biser, associate registrar
Frederick E. Ressler, B.A., associate registrar
Rodney E. Ressler, associate registrar
Edwin C. Eigenbrot, Jr., M.Ed., assistant registrar
Jeanne E. Phifer, assistant to the registrar

Administrative Systems Office

Juan A. Sanchez, B.S., director
Wayne Hoffman, assistant director
John H. Wachter, B.S., systems analyst
Robert E. Reidnauer, systems analyst
Roy Gruver, M.A., systems analyst

Alumni Association

James W. Niemeyer, B.S., executive director
Harry B. Ramsey, B.A., associate director and editor of the *Lehigh Alumni Bulletin*
Dennis R. Diehl, M.B.A., assistant executive director
Lucille Barrett, A.B., assistant editor, *Lehigh Alumni Bulletin*

Buildings and Grounds

Paul T. Miller, director
Kenneth Yeisley, assistant director
Donald J. Bergeron, assistant to the director

Business Offices

Donald W. Schmoyer, B.S., assistant treasurer
Joseph Petronio, B.S., bursar
Philip Clauser, B.S., assistant bursar
John L. Kemmerer, purchasing agent
Jeffrey D. Schmoyer, A.A.S., assistant purchasing agent
Timothy J. Hill, M.B.A., controller
Clark W. Hahn, B.A., associate controller
Larry M. Miley, B.S., assistant controller
Robert W. Bell, M.S., director, university bookstore
Edward L. Fehr, manager, university bookstore
Stephen J. Guttman, B.A., assistant manager, university bookstore

Intercollegiate Athletics and Recreation

William B. Leckonby, B.S., director
John N. Covert, B.S., assistant director and track coach
Gerald G. Leeman, B.A., assistant to the director and golf coach
N. Craig Anderson, M.S., business manager and ticket manager
John S. Steckbeck, M.Sc., associate director of intramurals and recreation
Barbara K. Lipkin, M.S., assistant director for women's athletics and varsity coach
Martha O. Barnett, B.S., women's swimming coach
J. Bruce Gardiner, M.Sc., swimming coach
Brian A. Hill, B.A., basketball coach
Joseph R. Kress, rifle coach
Annette K. Lynch, B.S., women's basketball coach
Steven R. Penman, M.S., hockey coach
Harry L. Price, M.Ed., lacrosse coach
Jack C. Ridge, B.S., tennis coach
Stanley R. Schultz, B.A., baseball coach
Emmanuel Tavormina, soccer coach
B. Thayer Turner, B.S., wrestling coach
Judith H. Turner, B.S., volleyball and lacrosse coach
John C. Whitehead, B.S., football coach

Health Service

Carl R. Ruch, M.D., director
Duane E. Stackhouse, M.D., associate director
Robert E. Lentz, M.D., associate director
Lucille H. Pleiss, R.N., administrative assistant
Doris Transue, R.N., nurse
Kathleen J.B. Januszewski, R.N., nurse
Adrienne Hughes, B.S., physical therapist

Mailing and Central Copying

Catherine M. Franklin, director

Office of Admission

Samuel H. Missimer, B.A., director
James W. McGeady, B.A., associate director
Debra H. Nesbitt, M.Ed., admissions counselor
Linda L. Turner, M.Ed., admissions counselor
Denese Walters, B.A., admissions counselor

Office of Community Relations

James W. Harper, M.S., director
Barbara J. Tallarico, administrative assistant

Office of Development

Robert M. Holcombe, M.S., director of development
John T. Fulton, M.S., director of annual giving
Michael G. Bolton, M.B.A., director of corporate and foundation resources
Ferdinand Thun, M.B.A., adviser, bequests and trusts

Office of Physical Planning

Anthony L. Corallo, M.Arch., director
Patricia A. Chase, B.A., assistant director

Office of Public Information

Samuel I. Connor, B.A., director
Roy Foster, Jr., B.A., assistant director
Joseph H. Whritenour, assistant director
Diane S. Yanis, B.S., public information associate

Office of the Vice President for Research

Joseph I. Goldstein, Sc.D., assistant vice president
Thomas L. Dinsmore, M.S., research administrator
Claire J. Roddy, A.B., research administrator

Office of Research

George R. Jenkins, Ph.M., director
John M. Cheezum, B.S., fiscal associate
Mary Jo Hill, M.A., editorial associate

Office of Undergraduate Financial Aid

William E. Stanford, B.A., director
Larry S. Sechney, B.S., assistant director
Wei-Chao R. Yen, B.A., data coordinator

Office of University Publications

George L. Beezer, director
Marvin H. Simmons, M.F.A., associate director
Michael Stoner, M.A., staff writer
Curtis D. Bauman, M.A., production assistant

Control Group

Gail A. Fullman, B.A., manager

Packer Memorial Church

The Rev. Hubert L. Flesher, M.A., university chaplain
Robert B. Cutler, M.A., organist

Personnel Office

Thomas J. Verbonitz, M.B.A., director of personnel and administrative services
Michael W. Kubinec, B.S., senior personnel associate
Maria Martinez, B.A., personnel associate
David E. Welty, B.A., personnel associate
Christopher J. Christian, B.S., manager, transportation services

Placement Services

Eugene R. Seeloff, Ed.D., director
Joan Davis, M.A., assistant director
Helen Z. Rayner, administrative assistant

University Counseling Service

Andrew J. Edmiston, Ph.D., director
Robert R. Panos, Ph.D., assistant director
William J. Sibley, M.Ed., counseling psychologist
Patricia A. Finady, B.A., administrative assistant

University Libraries

Berry G. Richards, M.L.S., director of libraries
Margaret L. Dennis, B.S. in L.S., assistant librarian for bibliographical services, Linderman Library
Mary G. Riley, M.S. in L.S., head, public services, Linderman Library
William J. Fincke, Jr., M.L.S., reference/interlibrary loan librarian, Linderman Library
Judith A. Mistichelli, M.S.L.S., senior reference librarian, Linderman Library
Georgia E. Raynor, M.S. in L.S., assistant librarian, cataloging
Catherine R. Flecksteiner, serials cataloger
Helen P. Mack, M.S.L.S., science cataloger
Judith E. McNally, M.L.S., humanities cataloger
Kenneth J. Veprek, M.S.L.S., technical coordinator—serials
Daniel J. Weine, A.M.L.S., social sciences cataloger
Lorraine C. Abel, manager of procurement and accounts
Olive Stengel, head, circulation service
Lynn K. Milet, M.L.S., media librarian, Media Center, Linderman Library
Sharon M. Siegler, M.L.S., head, public services, Mart Library
Christine Roysdon, M.S.L.S., senior reference librarian, Mart Library
Linda Khatri, M.L.S., reference librarian, Mart Library

University Police

Eugene Dax, chief

Those Responsible for Research and Related Units

Directors and staff members of the university's research centers and institutes are listed below. Full degree information may be found in the faculty and staff alphabetical listings on subsequent pages.

Center for the Application of Mathematics

Ronald S. Rivlin, Sc.D., director
Philip A. Blythe, Ph.D.
Dominic G. B. Edelen, Ph.D.
Gregory T. McAllister, Ph.D.
Eric P. Salathe, Ph.D.
Gerald F. Smith, Ph.D.
Eric Varley, Ph.D.
Anastasios Kydoniefs, Ph.D.
Kenneth N. Sawyers, Ph.D., executive officer
Ramamirtham Venkataraman, Ph.D.
Yakovos Kazakia, Ph.D.
J. David A. Walker, Ph.D.

Computing Center

Ben L. Wechsler, Ph.D., director
William R. Harris, M.B.A., associate director
Joseph P. Holzer, administrative assistant
John H. Morrison, operations manager
Louis P. Robinson, B.E., director of The Computer Associates Program and special projects manager
Gary E. McConnell, B.S., senior systems programmer
Robert L. Pettigrew, B.S., systems programmer
Robert A. Pfenning, M.B.A., educational coordinator
Carol D. Rauch, user services consultant
Steve G. Roseman, B.S., systems programmer
Ned A. Deily, B.A., B.S., systems programmer
William E. Schiesser, Ph.D., faculty associate

Center for Economic Education

Bruce R. Dalgaard, Ph.D., director

Energy Research Center

Edward K. Levy, Ph.D., director
Betzalel Avitzur, Ph.D.
Hugo S. Caram, Ph.D.
John C. Chen, Ph.D.
Brenda P. Egolf, M.A.
Fazil Erdogan, Ph.D.
Frederick M. Fowkes, Ph.D.
Sidney S. Herman, Ph.D.
Roy C. Herrenkohl, Ph.D.
K. Elaine Hoagland, Ph.D.
Robert L. Johnson, Ph.D.
Stanley H. Johnson, Ph.D.
Alvin S. Kanofsky, Ph.D.
Daniel Leenov, Ph.D.
Eugene J. London, B.S.M.E.
John R. McNamara, Ph.D.
Sudhakar Neti, Ph.D.
Michael R. Notis, Ph.D.
Alexis Ostapenko, Ph.D.
Alan W. Pense, Ph.D.
Louis J. Plebani, Jr., Ph.D.
Adrian F. Richards, Ph.D.
Richard Roberts, Ph.D.
Louis Robinson, Jr., B.E.
Robert G. Sarubbi, Ph.D.
William E. Schiesser, Ph.D.
George C. Sih, Ph.D.
Bruce M. Smackey, Ph.D.
Fred P. Stein, Ph.D.
Robert D. Stout, Ph.D.
Ramu K. Sundaram, Ph.D.
Theodore A. Terry, Ph.D.
Leonard A. Wenzel, Ph.D.

Fritz Engineering Laboratory

Lynn S. Beedle, Ph.D., director
George C. Driscoll, Jr., Ph.D., associate director
John W. Fisher, Ph.D., associate director
Bruce A. Laub, M.B.A., administrative associate
Sarah-Louise Melcher, B.A., administrative assistant to the director
John W. Fisher, Ph.D., director, fatigue and fracture division
Hsai-Yang Fang, Ph.D., director, geotechnical engineering division
Robert L. Johnson, Ph.D., director, hydraulics and environmental engineering division
Le-Wu Lu, Ph.D., director, building systems division
Ti Huang, Ph.D., director, structural concrete division
George C. Driscoll, Jr., Ph.D., director, structural connections division
Alexis Ostapenko, Ph.D., director, structural stability division
Roger C. Slutter, Ph.D., director, operations division
Celal N. Kostem, Ph.D., chairman, computer systems group
Kenneth R. Harpel, laboratory superintendent
Hugh T. Sutherland, instruments associate

associates. Arthur W. Brune, Ph.D., J. Hartley Daniels, Ph.D., George Irwin, Ph.D., Willard A. Murray, Ph.D., Alan W.

Pense, Ph.D., Richard Roberts, Ph.D., Lambert Tall, Ph.D., Paul J. Usinowicz, Ph.D., David A. VanHorn, Ph.D., Ben T. Yen, Ph.D., Richard N. Weisman, Ph.D., John D. Wood, Ph.D.

Center for Health Sciences

Institute for Pathobiology

Thomas C. Cheng, Ph.D., director; experimental and chemical parasitology; comparative immunology; invertebrate pathology
Edward J. Benz, M.D., medical microbiology
George P. Hoskin, Ph.D., comparative physiology; lipid biochemistry
Vincent G. Guida, Ph.D., helminth parasitology; lysosomal enzymes
George J. Jackson, Ph.D., nematode physiology; immunology; parasitology of foods
David A. Schoenberg, Ph.D., phagocytosis; cell surface recognition phenomena; schistosomiasis
Carl J. Sindermann, Ph.D., diseases of marine invertebrates and fish
Randall W. Snyder, Jr., M.D., gastrointestinal physiology; medical parasitology

Division of Biological Chemistry and Biophysics

Ned D. Heindel, Ph.D., director; medicinal chemistry, nuclear medicine; cancer chemotherapy; bioorganic chemistry
Brent W. Benson, Ph.D., radiation biophysics; structure of nucleic acids
Donald Burns, Ph.D., nuclear medicine
Frederick M. Fowkes, Ph.D., physical chemistry of biological surfaces
William E. Ohnesorge, Ph.D., clinical chemistry
Robert S. Rodgers, Ph.D., instrumentation; biomedical applications of computers
Jeffrey Sands, Ph.D., biophysics of viruses
Keith J. Schray, Ph.D., intermediary metabolism; enzyme kinetics
Stephen W. Schaffer, Ph.D., physiology and biochemistry of cardiac contractility, cardiac metabolism
James E. Sturm, Ph.D., radiochemistry as applied to living systems

Division of Bioengineering

Thomas C. Cheng, Ph.D., director *pro tempore*
Arturs Kalnins, Ph.D., physical properties of cell surfaces
Russell F. Benner, Ph.D., prosthetics
Nikolai Eberhardt, Ph.D., bioinstrumentation
Dean P. Updike, Ph.D., properties of biological surfaces
Eric P. Salathe, Ph.D., dynamics of microcirculation
John J. O'Connor, Ph.D., biomedical information retrieval
Charles R. Smith, Jr., Ph.D., mechanics of biological fluids

Division of Health Management and Policy Studies

Bruce M. Smackey, Ph.D., director; management and economics of health care
Josef M. Brozek, Ph.D., human nutrition; history of psychobiology
Alvin Cohen, Ph.D., public health economics
Frank T. Colon, Ph.D., public administration; emergency health delivery systems
George A. Dinsmore, Ph.D., application of systems simulation to health services delivery
John R. McNamara, Ph.D., public health economics and modeling
John H. Ellis, Ph.D., history of public health and medicine
John J. O'Connor, Ph.D., biomedical information retrieval systems
Eli Schwartz, Ph.D., cost-benefit analysis of medical research; health service administration; hospital administration
Albert C. S. Shen, Ph.D., econometrics; health economics
Roger D. Simon, Ph.D., quantitative techniques for the study of sanitary services' morbidity and mortality rates
Zdenek J. Slouka, Ph.D., international health programs
Bruce M. Smackey, Ph.D., economics of health services
Robert C. Williamson, Ph.D., medical and public health sociology

Center for Information and Computer Science

Donald J. Hillman, M.Litt., director
Robert F. Barnes, Ph.D., mathematical linguistics
Peter G. Beidler, Ph.D., Humanities Perspectives on Technology
Samuel L. Gulden, M.A., computer science
Ned D. Heindel, Ph.D., biomedical information
Andrew J. Kasarda, Ph.D., information systems
Sutton Monro, B.S., statistics
John J. O'Connor, Ph.D., information retrieval
Herbert Rubenstein, Ph.D., psychology and linguistics

associates. Lynn S. Beedle, Ph.D., tall buildings information system; Bruce D. Fritchman, Ph.D., communication systems; Berry G. Richards, M.L.S., library systems; Robert C. Williamson, Ph.D., man-machine interface

research associate. Judith Lichtman

Center for Marine and Environmental Studies

James M. Parks, Ph.D., director
Bobb Carson, Ph.D., oceanic sedimentology
Edward B. Evenson, Ph.D., environmental geology
Vincent G. Guida, Ph.D., director, The Wetlands Institute
Sidney S. Herman, Ph.D., marine biology
Michael C. Hughes, Ph.D., environmental analytical chemistry
Robert L. Johnson, Ph.D., environmental engineering
Joseph R. Merkel, Ph.D., marine biochemistry
Adrian F. Richards, Ph.D., director, marine geotechnical laboratory

associates. Bruce R. Hargreaves, Ph.D.; K. Elaine Hoagland, Ph.D.; Alister K. MacPherson, Ph.D.; Willard A. Murray, Ph.D.; Hayden N. Pritchard, Ph.D.; Theodore A. Terry, Ph.D.; Paul J. Usinowicz, Ph.D.; Wesley J. Van Sciver, Ph.D.

Materials Research Center

Donald M. Smyth, Ph.D., director
David A. Thomas, Sc.D., associate director, and director, materials liaison program
Sidney R. Butler, Ph.D., director, electronic materials laboratory
Walter E. Dahlke, Ph.D., electronic materials laboratory
Frank J. Feigl, Ph.D., electronic materials laboratory
Joseph I. Goldstein, Sc.D., director, electron optical laboratory
Richard W. Hertzberg, Ph.D., director, mechanical behavior laboratory
Frank H. Hielscher, Ph.D., electronic materials laboratory
John A. Manson, Ph.D., director, polymer laboratory
Michael R. Notis, Ph.D., director, ceramic research laboratory
Subhash H. Risbud, Ph.D., ceramic research laboratory
Richard Roberts, Ph.D., mechanical behavior laboratory
Leslie H. Sperling, Ph.D., polymer laboratory
Richard M. Spriggs, Ph.D., ceramic research laboratory
David B. Williams, Ph.D., electron optical laboratory

Center for Social Research

Roy C. Herrenkohl, Ph.D., director; director, behavioral research program
R. Allen Moran, Ph.D., assistant director
J. Richard Aronson, Ph.D., director, business and economics program
Arthur E. King, Ph.D., director, urban technology program
Zdenek J. Slouka, Ph.D., director, international studies program

associates. Carol Barner-Barry, Ph.D.; Brenda Egolf, M.A.; Ellen C. Herrenkohl, Ph.D.; John R. McNamara, Ph.D.; Edward P. Morgan, Ph.D.; Monica Newman, M.A.; Laura K. Olson, Ph.D.; Lawrence Ransel, M.A.; Robert Rosenwein, Ph.D.; Eli Schwartz, Ph.D.; Robert J. Thornton, Ph.D.; Robert C. Williamson, Ph.D.

Center for Surface and Coatings Research

Henry Leidheiser, Jr., Ph.D., director
John W. Vanderhoff, Ph.D., associate director, coatings
Kamil Klier, Ph.D., associate director, surfaces

Eugene M. Allen, Ph.D., professor of chemistry and director, color laboratory
Mohamed S. El-Aasser, Ph.D., associate professor of chemical engineering, co-director, Emulsion Polymers Institute
Kamil Klier, Ph.D., professor of chemistry and director, catalysis laboratory
Henry Leidheiser, Jr., Ph.D., professor of chemistry and director, corrosion laboratory
Anthony J. McHugh, Ph.D., associate professor of chemical engineering, Emulsion Polymers Institute
Fortunato J. Micale, Ph.D., associate professor of chemistry and director, colloid laboratory
Cesar Silebi, Ph.D., assistant professor of chemical engineering, Emulsion Polymers Institute
Gary W. Simmons, Ph.D., associate professor of chemistry and director, surface analysis laboratory
John W. Vanderhoff, Ph.D., professor of chemistry; director, National Printing Ink Research Institute; co-director, Emulsion Polymers Institute
Robert P. Wei, Ph.D., professor of mechanical engineering and mechanics and director, environment-sensitive fracture laboratory
Albert C. Zettlemoyer, Ph.D., distinguished professor of chemistry and provost

Research scientists. Ning-Huat Chan, Ph.D.; Kenneth A. Earhart, M.S.; Jacqueline M. Fetsko, M.S., administrative assistant; Richard G. Herman, Ph.D.; Anthony M. Schwartz, Ph.D.

Visiting scientists. Kunio Esumi, Ph.D.; Tetsuya Imamura, Ph.D.; Hans Kast, Ph.D.; Ichiro Suzuki, Ph.D.

Research associates. Robert G. Hart, Ph.D.; Ming-Che Lu, Ph.D.; Subodh C. Misra, Ph.D.

Emulsion Polymers Institute

John W. Vanderhoff, director, Ph.D.
Mohamed S. El-Aasser, Ph.D.
Anthony J. McHugh, Ph.D.
Fortunato J. Micale, Ph.D.
Olga L. Shaffer, M.S.
Kenneth A. Earhart, M.S.
John A. Manson, Ph.D.

Institute for Fracture and Solid Mechanics

George C. M. Sih, Ph.D., director
Fazil Erdogan, Ph.D.
Ronald J. Hartranft, Ph.D.
Peter D. Hilton, Ph.D.
Arturs Kalnins, Ph.D.
Robert A. Lucas, Ph.D.
Richard Roberts, Ph.D.
Robert G. Sarubbi, Ph.D.
Dean P. Updike, Ph.D.
Robert P. Y. Wei, Ph.D.

Lawrence Henry Gipson Institute for Eighteenth-Century Studies

Lawrence H. Leder, Ph.D., and
E. Anthony James, Ph.D., coordinators
Michael D. Baylor, Ph.D.
Jan Fergus, Ph.D.
Edward J. Gallagher, Ph.D.
John W. Hunt, Ph.D.
Joseph F. Libsch, Ph.D.
James S. Saeger, Ph.D.
D. Alexander Waldenrath, Ph.D.
W. Ross Yates, Ph.D.
Albert C. Zettlemoyer, Ph.D.

Institute for Metal Forming

Betzalel Avitzur, Ph.D., director

National Printing Ink Research Institute

John W. Vanderhoff, Ph.D., director
Jacqueline M. Fetsko, M.S.
Eugene M. Allen, Ph.D.
Fortunato, J. Micale, Ph.D.
Mohamed S. El-Aasser, Ph.D.
Jean S. Lavelle, B.S.
Bernadine Dancho
Kenneth A. Earhart, M.S.

Sherman Fairchild Laboratory for Solid-State Studies

Frank J. Fiegl, Ph.D., coordinator
Sidney R. Butler, Ph.D.
Walter E. Dahlke, Ph.D.
W. Beall Fowler, Ph.D.
Frank H. Hielscher, Ph.D.
John G. Simmons, Ph.D., D.Sc., Sherman Fairchild professor of solid-state studies
Wesley R. Smith, Ph.D.
Donald M. Smyth, Ph.D.
Wesley J. Van Sciver, Ph.D.
George D. Watkins, Ph.D., Sherman Fairchild professor of solid-state studies

Small Business Center

John W. Bonge, Ph.D., director
John E. Stevens, Ph.D., associate director
Marc J. Dollinger, M.B.A., program administrator

Institute of Thermo-Fluid Engineering and Science

John C. Chen, Ph.D., director
Douglas E. Abbott, Ph.D.
Forbes T. Brown, Ph.D.
Hugo Caram, Ph.D.
Curtis W. Clump, Ph.D.
Stanley H. Johnson, Ph.D.
Edward K. Levy, Ph.D.
Eugene J. London, B.S.M.E.
Alister K. MacPherson, Ph.D.
Anthony J. McHugh, Ph.D.
Raymond J. Emrich, Ph.D.
Sudhakar Neti, Ph.D.
Donald O. Rockwell, Ph.D.
Robert G. Sarubbi, Ph.D.
William E. Schiesser, Ph.D.
Charles R. Smith, Ph.D.
Fred P. Stein, Ph.D.
Ramu Sundaram, Ph.D.
Leonard A. Wenzel, Ph.D.
J. David Walker, Ph.D.
Wesley Smith, Ph.D.

Wetlands Institute, The

Vincent G. Guida, Ph.D., director; physiology of oceanic and estuarine animals, ecology of symbiosis and parasitism
Saul B. Barber, Ph.D., physiology of invertebrates
Barry Bean, Ph.D., microbial genetics and behavior
David M. Bell, Ph.D., behavior of marine animals
Bobb Carson, Ph.D., geological oceanography
Bruce R. Hargreaves, Ph.D., environmental physiology
Sidney S. Herman, Ph.D., biological oceanography, marine ecology, food chain relationships
K. Elaine Hoagland, Ph.D., marine ecology and reproductive strategies
Robert L. Johnson, Ph.D., tertiary sewage treatment
Steven S. Krawiec, Ph.D., genetic organization of micro-organisms
Richard G. Malsberger, Ph.D., viral diseases of fish
Joseph R. Merkel, Ph.D., biochemistry, of marine bacterial enzymes
James M. Parks, Ph.D., beach preservation
Hayden N. Pritchard, Ph.D., marine botany
J. Donald Ryan, Ph.D., geological history of coastal salt marshes, sedimentation

Faculty and Staff

The date after the name is the date of appointment to continuous service on the Lehigh faculty or staff; the second date, when the first fails to do so, indicates the date of appointment to the present professional rank. Where the name of the institution awarding a higher-level degree is not given, the institution is the same one which awarded the previous degree listed.

P.E. indicates certification as a professional engineer, C.P.A. indicates certified public accountant.

A

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W. Ross Yates (1955, 1963), professor of government. B.A., Oregon, 1948; M.A., 1949; Ph.D., Yale, 1956.

Kenneth M. Yeisley (1974), assistant director of buildings and grounds.

Bung-Tseng Yen (1957, 1977), professor of civil engineering. B.S., National Taiwan (Taiwan), 1955; M.S., Lehigh, 1959; Ph.D., 1963.

Wei-Chao R. Yen (1978), data coordinator. B.A., National Taiwan (Taiwan), 1968.

Thomas E. Young (1958, 1966), professor of chemistry. B.S., Lehigh, 1949; M.S., 1950; Ph.D., Illinois, 1952.

Z

Daniel Zeroka (1967, 1974), associate professor of chemistry. B.S., Wilkes, 1963; Ph.D., Pennsylvania, 1966.

Albert C. Zettlemoyer (1941, 1969), provost and vice president, and distinguished professor of chemistry. B.S., Lehigh, 1936; M.S., 1938; Ph.D., M.I.T., 1941; D.Sc., Clarkson, 1965; LL.D., The China Academy (Taiwan), 1974.

Emory W. Zimmers, Jr. (1969, 1976), associate professor of industrial engineering. B.S., Lehigh, 1966; B.S., 1967; M.S., 1967; Ph.D., 1973.

Perry A. Zirkel (1977), dean of the School of Education, and professor of education. B.A., S.U.N.Y. at Oswego, 1966; M.A., Connecticut, 1968; Ph.D., 1972; J.D., 1976.

Faculty Emeriti

The first year given is the year in which the person commenced employment with Lehigh University. In some cases, individuals left and returned, so that an additional date is given. The final date in all cases is the year in which the person achieved emeritus status.

Carl E. Allen (1930, 1964), professor emeritus of accounting. B.S., Illinois, 1923; M.S., 1925; Ph.D., 1930. C.P.A., Pennsylvania, 1939.

Edward D. Amstutz (1938, 1972), Howard S. Bunn distinguished professor emeritus of chemistry. B.S., Wooster, 1930; M.S., Inst. of Paper Chemistry, 1932; Ph.D., Cornell, 1936; D.Sc., Wooster, 1969.

Ray L. Armstrong (1946, 1975), professor emeritus of English. B.A., Williams, 1930; B.A., Oxford, 1932; M.A., 1936; Ph.D., Columbia, 1941.

Lloyd W. Ashby (1966, 1971), professor emeritus of education. A.B., Hastings (Nebraska), 1927; M.A., Columbia Teachers, 1935; Ed.D., 1950.

Allen J. Barthold (1939, 1967), professor emeritus of romance languages. B.A., Lehigh, 1921; Ph.D., Yale, 1931.

Lois R. Benson (1955, 1971), chief nurse administrative assistant emeritus, health service. B.A., Michigan, 1932; R.N., Allentown Hospital, 1939.

Robert D. Billinger (1923, 1965), associate professor emeritus of chemistry. B.S., Lehigh, 1921; M.S., 1925; Ph.D., Cincinnati, 1929.

Charles W. Brennan (1955, 1974), dean of students emeritus and professor emeritus of industrial engineering. B.S., Alabama, 1934; M.B.A., 1953.

Natt B. Burbank (1964, 1971), professor and assistant dean emeritus, School of Education. A.B., Vermont, 1925; M.A., Columbia, 1931; LL.D., Vermont, 1963.

Clarence B. Campbell (1947, 1957, 1974), dean of residence emeritus. B.A., Temple, 1937; M.A., Lehigh, 1947.

Glenn J. Christensen (1939, 1976), university distinguished professor emeritus. B.A., Wooster, 1935; Ph.D., Yale, 1939; LL.D., Col. of Notre Dame (Maryland), 1966.

Raymond G. Cowherd (1956, 1975), professor emeritus of history. A.B., William Jewell, 1933; M.A., Pennsylvania, 1936; Ph.D., 1940.

Cloyd Criswell (1947, 1973), professor emeritus of English. B.S., in Ed., Millersville State, 1933; M.A., N.Y.U., 1937.

Cassius W. Curtis (1946, 1971), professor emeritus of physics. A.B., Williams, 1928; Ph.D., Princeton, 1936.

Edward H. Cutler (1930, 1968), associate professor emeritus of mathematics. A.B., Harvard, 1925; A.M., 1926; Ph.D., 1930.

H. Barrett Davis (1946, 1972), professor emeritus of speech. B.L.I., Emerson, 1929; Cert., American Academy of Dramatic Arts, 1930; M.A. (Hon.), Emerson, 1958.

Warren M. Davis (1971, 1974), lecturer in education. A.B., Ohio, 1933; M.A., Ohio State, 1939; Ph.D., 1952.

Albert W. de Neufville (1948, 1967), associate professor emeritus of mechanics. Dipl. Ing., Berlin (Germany), 1922; M.S., Stevens, 1948; Ph.D., Lehigh, 1952.

Herbert M. Diamond (1927, 1964), professor emeritus of economics. B.A., Yale, 1914; Ph.D., 1917.

Ernest N. Dilworth (1949, 1975), professor emeritus of English. Ph.B., Kenyon, 1933; M.A.,Pittsburgh, 1937; Ph.D., Columbia, 1948.

William J. Eney (1936, 1971), Joseph T. Stuart professor emeritus of civil engineering. B.S., Johns Hopkins, 1927; M.S., Lehigh, 1938. P.E., Pennsylvania, 1939.

James W. Eppes (1950, 1974), professor emeritus of mechanical engineering. B.A., Virginia, 1928; M.E., Cornell, 1931; M.S. in M.E., Lehigh, 1943.

Alan S. Foust (1952, 1976), professor emeritus of chemical engineering. B.S., Texas, 1928; M.S., 1930; Ph.D, Michigan, 1938. P.E., Michigan, 1947.

Robert T. Gallagher (1942, 1976), professor emeritus of mining engineering; associate dean emeritus, College of Engineering and Physical Sciences. B.S., Penn State, 1927; M.A., Missouri, 1938; D.E.M., Colorado School of Mines, 1941. P.E., Pennsylvania, 1945; New Jersey, 1955.

Elmer W. Glick (1949, 1978), vice president and treasurer emeritus. B.A., Lehigh, 1933; LL.D. (Hon.), 1978.

George D. Harmon (1925, 1964), professor emeritus of American history. B.A., Duke, 1921; M.A., 1922; Ph.D., Pennsylvania, 1930.

Robert A. Harrier (1951, 1970), executive secretary emeritus, alumni association. E.M., Lehigh, 1927.

Ladd E. Hoover (1960, 1967), associate director emeritus, university health service. B.Sc., Nebraska, 1924; M.D., 1926.

Thomas E. Jackson (1946, 1978), professor emeritus of mechanical engineering and mechanics. B.S., Carnegie-Mellon, 1934; M.S., Lehigh, 1937. P.E., Pennsylvania, 1946.

Edwin J. Keim (1973, 1976), associate professor emeritus of education. B.S., West Chester State, 1934; M.S., Pennsylvania, 1940; Ed.D., 1951.

Nancy Larrick (1964, 1976), adjunct professor emeritus of education. B.A., Goucher, 1930; M.A., Columbia, 1937; Ed.D., N.Y.U., 1955.

Voris V. Latshaw (1931, 1969), associate professor emeritus of mathematics. B.A., Indiana, 1927; A.M., 1928; Ph.D., 1930.

John D. Leith (1945, 1964, 1966), dean of students emeritus. A.B., North Dakota, 1920; A.M., Columbia, 1924.

James D. Mack (1946, 1978), professor and curator of rare books emeritus. B.A., Lehigh, 1938; M.A., 1949.

Joseph A. Maurer (1947, 1977), professor emeritus of classics. B.A., Moravian, 1932; M.A., Lehigh, 1936; Ph.D., Pennsylvania, 1948.

Ethel M. McCormick (1964, 1969), associate professor of education. B.S., Northwestern 1931; M.Ed., Penn State, 1941; D.Sc.Ed., Cedar Crest, 1963.

George W. McCoy, Jr. (1956, 1970), university physician emeritus. B.S., Pennsylvania, 1929; M.D., 1932.

Albert C. Molter (1960, 1974), purchasing agent emeritus. B.S., Norwich, 1928.

Harvey A. Neville (1927, 1964), president emeritus. A.B., Randolph-Macon, 1918; M.A., Princeton, 1920; Ph.D., 1921; LL.D. (Hon)., Randolph-Macon, 1952; L.H.D. (Hon.), Moravian, 1962; LL.D. (Hon.), Lafayette, 1962; Sc.D. (Hon.), Lehigh, 1965.

Joseph C. Osborn (1955, 1977), professor emeritus of mechanics. B.S.M.E., Purdue, 1933; M.S., Michigan, 1946; Sc.D., M.I.T., 1957.

Bradford B. Owen (1945, 1974), professor emeritus of biology. B.A., Williams, 1934; M.A., 1936; Ph.D., Harvard, 1940.

A. Everett Pitcher (1938, 1978), university distinguished professor emeritus of mathematics. A.B., Case-Western Reserve, 1932; A.M., Harvard, 1933; Ph.D., 1935; D.Sc. (Hon.), Case-Western Reserve, 1957.

Estoy Reddin (1964, 1977), professor emeritus of education. B.S., Pennsylvania, 1932; M.S., 1956; Ed.D., 1964.

Edgar H. Riley (1926, 1958), associate professor emeritus of English. A.B., Cornell, 1915; Ph.D., 1925.

Raymond B. Sawyer (1946, 1964), associate professor emeritus of physics. Ph.B., Ripon, 1921; M.S., Wisconsin, 1925; Ph.D., Chicago, 1930.

Ernest B. Schulz (1927, 1965), professor emeritus of political science. B.S., Michigan, 1920; M.A., 1921; Ph.D., 1927.

Charles A. Seidle (1948, 1970), vice president emeritus. B.A., Pittsburgh, 1931; M.A., Columbia, 1936; Ed.D., 1948.

Edith A. Seifert (1923, 1969), bursar emeritus.

J. Burke Severs (1927, 1969), distinguished professor emeritus of English. A.B., Rutgers, 1925; A.M. Princeton, 1927; Ph.D, Yale, 1935. Fellow of the Royal Society of Arts, 1962.

Margaret M. Seylar (1966, 1977), professor emeritus of education. B.S., Kutztown, 1947; M.A., Lehigh, 1957.

E. Kenneth Smiley (1934, 1964), vice president emeritus. A.B., Bowdoin, 1921; M.A., Lehigh, 1935; L.H.D. (Hon.), Moravian, 1947; LL.D. (Hon.), Waynesburg, 1952.

Wilbur D. Bernhart Spatz (1946, 1973), professor emeritus of physics. B.S., Lafayette, 1930; M.S., Purdue, 1934; Ph.D., N.Y.U., 1943.

Carl F. Strauch (1934, 1974), distinguished professor emeritus of English. A.B., Muhlenberg, 1930; M.A., Lehigh, 1934; Ph.D., Yale, 1946; D.H.L. (Hon.), Muhlenberg, 1973.

Merle W. Tate (1965, 1974), professor emeritus of education. A.B., Central Wesleyan, 1926; M.A., Montana, 1943; Ed.M., Harvard, 1946; Ed.D., 1947.

Everett A. Teal (1945, 1975), director emeritus of placement services. B.S., Ball State, 1932; M.A., Columbia, 1941.

Wendell P. Trumbull (1957, 1974), professor emeritus of accounting. B.S., Illinois, 1937; M.A., Michigan, 1941; Ph.D., 1954. C.P.A., Mississippi, 1949.

Lawrence Whitcomb (1930, 1965), associate professor emeritus of geology. Ph.B., Brown, 1922; A.M., Princeton, 1928; Ph.D., 1930.

Ralph C. Wood (1958, 1967), professor emeritus of German. B.A. and B.E., Cincinnati, 1928, M.A., 1930; Ph.D., Cornell, 1933.

Charles K. Zug (1961, 1975), adviser emeritus on bequests, trusts and insurance. B.S. in I.E., Lehigh, 1927; B.S. in E.E., 1927.

In Memoriam

The university notes with regret the deaths of the following members of the faculty during the past two years.

J. Lynnford Beaver, professor emeritus of electrical engineering, November 15, 1977.

Allison Butts, professor emeritus of metallurgy, June 30, 1977.

Aurie N. Dunlap, professor emeritus of international relations, May 19, 1977.

George D. Farne, assistant professor emeritus of romance languages, September 7, 1978.

Laszlo K. Nyiri, associate professor of chemical engineering, January 31, 1979.

Basil W. Parker, professor emeritus of biology, August 15, 1978.

Howard C. Pieper, physician emeritus of university health service, April 14, 1977.

Judson G. Smull, associate professor emeritus of chemistry, April 21, 1978.

Milton C. Stuart, professor emeritus of mechanical engineering, November 3, 1978.

Francis J. Trembley, professor emeritus of ecology, April 27, 1978.

John S. Tremper, associate professor emeritus of German, May 18, 1978.

Ralph N. Van Arnam, associate professor emeritus of astronomy, August 10, 1977.

Fenders truly served as mud guards when automobiles offered scant protection for passengers.

VII. The Index: Where to Find Facts

A volume such as this is necessarily a compendium of information serving many people in many ways. The reader may find it useful to peruse the edition in its entirety, thereby possibly locating information which could become helpful in planning the university career. Those desiring information on specific subject areas may prefer to use the index which follows.

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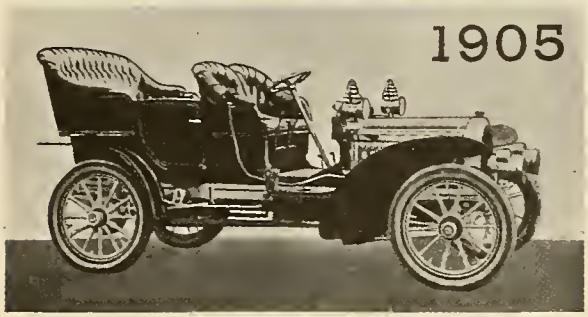

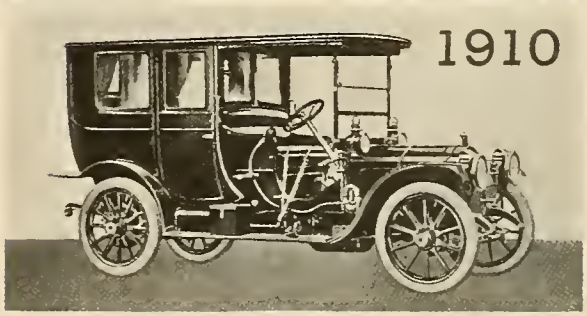

Of Special Interest

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